ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Adrian <adrianhey@gmail.com> Sun, Oct 14, 2012 at 12:23 PM
To: ITP.Goldstein@noaa.gov

Please stop any testing off the coast of California. It would appear that the damage that will be done to the marine life there will be catastrophic. We need to protect our valuable ocean life not harm it by doing testing that we know will likely cause irreparable harm. Please do not allow this testing to go ahead. It is just inexcusable what we think we are allowed to do to marine life.

Mrs. Adrian Hey
17 Kirk Drive
London, ON
Canada

Fwd: Seismic testing

Pr Webmaster <pr.webmaster@noaa.gov> Thu, Sep 13, 2012 at 9:44 AM
To: Howard Goldstein <howard.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Allegra Perea** <allegrasd@gmail.com>
Date: Wed, Sep 12, 2012 at 11:09 PM
Subject: Seismic testing
To: "pr.webmaster@noaa.gov" <pr.webmaster@noaa.gov>

Please as a resident of los Osos and a lover of nature PlEASE don't let pg&e test, we know they don't care about us and this will have devastating effects on our delicate ecosystem and hurt our community.
Thank you
Allegra Perea
Have a great day!

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Seismic Testing

Howard Goldstein <howard.goldstein@noaa.gov> Tue, Oct 16, 2012 at 9:07 AM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: <waterbabytwelve@gmail.com>
Date: Tue, Oct 16, 2012 at 1:22 AM
Subject: Seismic Testing
To: Howard.Goldstein@noaa.gov

Hello,
I am a resident and longtime surfer of San Luis Obispo county in California. I am concerned about the possibility of seismic testing along our coastline. Why are we going to do more seismic tests when there is already data that should be studied? I've lived here my entire life and I really enjoy the abundance of sea life that exists in our area. I was taught to respect the earth and all its creatures. This testing is harmful to all creatures marine and human! Please put a stop to this testing! Look at the data already taken and find another way to seismically test the Diablo area!

Best Wishes,
Amber Eckert

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Amul Mehta <amuline13@hotmail.com> Sun, Oct 14, 2012 at 10:51 PM
To: itp.goldstein@noaa.gov, itp.goldstein@noaa.gov.com

For Attention: **Mr. P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service.**

Dear Mr. P. Michael Payne,

RE: Marine Geophysical Survey off the Central Coast of California, November to December, 2012

It is with deep concern that I note the willingness of authorities to ignore the threats of the planned marine geophysical survey off the central coast of California, Nov – Dec 2012. The projected total of 33 MILLION animals being affected is serious in the extreme and cannot be ignored. Neither can any benefit from this exploitation in any way compensate for the impact: money cannot replace life, and deliberate ecocide is both irresponsible and unforgivable.

I hesitate to even touch on how unethical it is to manipulate the public into believing that such an action is for their good or unavoidable. Apart from the many deaths and injuries that WILL result, the sheer trauma this will cause to marine animals should already prohibit these actions even being considered. Finally: these animals are not the possessions of the US government. Many are migratory, and all form part of the ecosystem we all hold as a common heritage.

We owe it to our children, if nothing else, not to continue destroying and exploiting our environments through what boils down to greed. Responsible, ethical, transparent actions would require that both the Navy and Big Oil should be required to prove with 100% certainty that their activities DO NOT cause ANY harm to marine life before any consideration of proceeding should be taken.

My concerns:

1. Proposal downplays the potential effect on marine life including fish, invertebrates and marine mammals.

2. Important studies that linked seismic surveys to strandings are not mentioned in proposal. Specifically the report by Gentry (2000) called "**Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000**" is not mentioned, let alone discussed in detail. Report by Malakoff 2002 called **"Suit ties whale deaths to research cruise" (Gulf of California 2002)** only mentioned briefly without significant discussion. Other occurrences such as Madagascar stranding are not mentioned at all.

These are documented cases that have not been mentioned in proposal

1. Mozambique 2006,

2. Gulf of California, 2002

3. Galapagos Islands, 2000

4. Madagascar, 2008

5. Peru, 2012

6. Interesting Statistics from Australia (2002-2004)

3. Crucial study that showed **Cardiorespiratory Changes in Beluga Whale in Response to Acoustic Noise** is not even mentioned in proposal. In this study belugas were exposed to noise at much lower level than is planned in California and the animal demonstrated severe tachycardia "at lower noise intensities (as low as 140 dB);"

4. This proposal is rushed and the levels of impact are not investigated enough and not accessed based on the best scientific evidence available.

5. The company's planned actions lack transparency, they should be required to fully and publicly disclose where activities take place, what equipment will be used, exact Sound Pressure Levels, when activities will take place. Additionally, marine mammal observers' logs where they record all marine mammal sightings should be publicly available.

6. The proposal lacks specifics of how strandings will be investigated. It does not include what protocol of stranding investigation will be, what independent organizations will investigate strandings, who and in what manner will look for the evidence of acoustic trauma, decompression sickness related embolism, hemorrhage, etc.

7. NMFS should deny the permit based on omission of the best scientific evidence available and inadequate assessment of impact on marine life.

Bottom Line:

1. MASS AND SINGLE STRANDINGS ARE NOT INVESTIGATED AND NOBODY SEARCHES FOR EVIDENCE TO LINK BIG OIL OR THE NAVY TO STRANDINGS.

2. BIG OIL (AND NAVY) DO NOT DISCLOSE WHERE, WHEN AND WHAT THEY HAVE BEEN DOING AND NOBODY ASKS THEM TO SHARE THIS INFORMATION PUBLICLY.

With such huge gaps in data, with strandings going down not being investigated and with Big Oil/Navy not being required to disclose data about their activities, it is irresponsible, wrong and iunethical to grant these permits, especially for sanctuaries and protected areas. This is insanity. Two recent examples: Peru die off and Black Sea die off.

Please submit my comments for consideration before reaching a decision, and may I ask that these comments be posted to http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications, without change, as per your guidelines. Please feel free to contact me should you have any queries.

Here are the links for the above points:

· **Suit Ties Whale Deaths to Research Cruise** by David Malakoff, Science 25 October 2002: 722-723. http://www.sciencemag.org/content/298/5594/722.citation

· **Mozambique 2006** http://www.iol.co.za/scitech/technology/seismic-float-twists-stranding-of-dolphins-1.301955

· **Gulf of California 2002 = Suit Ties Whale Deaths to Research Cruise** by David Malakoff, Science 25 October 2002: 722-723. http://www.sciencemag.org/content/298/5594/722.citation

· **Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000**

· *by Roger L. Gentry, November 4, 2002* http://www.nmfs.noaa.gov/pr/pdfs/health/galapagos_stranding.pdf

· **Whales stranded off Madagascar** By Jonny Hogg BBC News, Antananarivo http://news.bbc.co.uk/2/hi/africa/7443559.stm

· Peru 2012 – Medical findings https://docs.google.com/file/d/0BzPA6tiYhZyhX1l6T1Q5MHZqd1U/edit?pli=1#

· **Interesting Statistics from Australia (2002-2004)** Oceania Strandings http://www.whales.org.au/strandings/oceania/index.html

· **Cardiorespiratory Changes in Beluga in Response to Acoustic Noise**

· **O. I. Lyamin*a*, *b*, *c*, S. M. Korneva*b*, V. V. Rozhnov*a*, and L. M. Mukhametov*a*, *b***

· Presented by Academician D.S. Pavlov June 15, 2011 http://beluga.sevin-expedition.ru/netcat_files/106/57/11_Lyamin_ECG_acoustic_noise_beluga_DAN_E.pdf

Thank you,

Kind Regards,

Amul Mehta
+919773697891
amuline13@hotmail.com
Mumbai, India

Please Do Not Print Any Documents Unless U Really Need To!!! Lo<3e Your Planet!!! :)

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Amy Scott <aerscott@hotmail.co.uk> Sun, Oct 14, 2012 at 3:36 PM
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>

For the attention of P. Michael Payne, Chief, Permits and Conservation division, office of protected resources, National Marine Fisheries Service,

Please do not allow the seismic testing off the coast of California, the effects will undoubtedly be catastrophic for the marine environment.
All plant and animal life will suffer, either directly or through the decline or removal of their food sources.
The sensitive Eco-systems are unlikely to repair themselves adequately after testing so the area will never be the same again.
For marine mammals whose whole existence is reliant on echo location,it will either kill them instantaneously or damage their senses & lead to death by stranding or starvation.
Seismic testing is not essential, so please do not allow this to start a potential avalanche of environmental disaster.
Thank you for your time
Yours faithfully
Amy Scott
UK

Sent from my iPhone

ITP Goldstein <itp.goldstein@noaa.gov>

Testing

ben lovejoy <benlovejoy@yahoo.com> Sun, Sep 30, 2012 at 3:03 PM
Reply-To: ben lovejoy <benlovejoy@yahoo.com>
To: "itp.goldstein@noaa.gov" <itp.goldstein@noaa.gov>

Further needless destruction of marine life is not acceptable! Deliberate mass killing of sea life to continue the production of the most toxic substance on the planet with no waste disposal solution is just plain nuts! We can't even figure out how to build a sign for nuclear waste dumps that will be able to warn people in the future that may not understand an ancient language like English.

ITP Goldstein <itp.goldstein@noaa.gov>

PG&E seismic testing on the Central Coast

Ben Terra <fishinfreakben@gmail.com> Sun, Oct 14, 2012 at 6:47 PM
To: ITP.Goldstein@noaa.gov

Thank you for taking the time to consider the important contributions citizens have to make to protecting our oceans.

2 attachments

LETTER TO NMFS DEREL.doc
18K

Fisherman letter NOAA.doc
23K

NOAA/NMFS, P. Michael Payne October 12, 2012

My name is Richard Derel Terra. I have been working on the ocean for 38 years since 1974, and of that time, 34 years as a captain. I have studies in Marine Biology, and have held a USCG Master License since passing the exam for the 500 - ton Mineral and Oil Master License. My son, Benjamin Terra is a fourth generation of fisherman in our family. My Grandfather worked on the Star of New Zealand, which is the sister ship to the Star of India moored in San Diego.

In representation of C.O.A.S.T. (Citizens Opposing Acoustic Seismic Testing), I am writing this letter in protest of PG&E's proposed seismic testing survey of our local waters in San Luis Obispo County. The Pacific Star recently finished low level testing. It should be noted that the vessel's A.I.S. system was not on during much of its operation, and we have had several harbor porpoise wash up on the beach recently. I have never seen or heard of this many in my 57 years living in Morro Bay. The Pacific Star's recent testing was conducted around 135 decibels. Local fishermen have noticed a recent drop in catch. One fisherman who averages 75 pounds to 100 pounds a day had only 10 pounds for an all day effort.

The high intensity testing is to be 250 decibels. Considering the exponential graduations of the decibel scale, 250 decibels will be exactly 4096 times louder than the low level survey. The second vessel will be towing 18 air cannons, firing every 5 seconds, for 12 days, which adds up to 207,360 blasts. The Hamby 2004 DBL conversion chart shows 248 DBL's to be equivalent to the atomic bomb blasts of Hiroshima and Nagasaki of World War Two. 207,360 air gun blasts equal to the sound intensity of those atomic bombs. The vessel will be in depth as shallow as 75 feet, with the air cannons 30 feet below the surface. This means that there will only be 45 feet between the air cannons and the reefs in its path. We have many local seamounts that fall under your jurisdiction. The Church Rock area is very abundant with adult fish. Many of these fish are among the endangered and threatened species of Boccaccio, Canary, and Yellow eye Rockfish. Recent ROV surveys of these local areas revealed flourishing abundant reefs. It must also be considered that all sebastes species of rockfish have been shown to swim downward as an effect of seismic testing in previous case studies. That is to say, the rockfish do not swim away horizontally to escape the sound. They swim downward as far as the bottom, and then they sit there. This means there would be massive mortality for endangered rockfish in protected RCA waters if the high intensity testing is allowed to happen.

If you permit this project, you will be in violation of your own laws, just as the Fish & Game would be if they were to grant permits for this project. During the September 24th F&G commission meeting, PG&E's representative Mark Krauss clearly stated that they did not want adult fish kill to be able to stop the project. The fishermen of this area have aboded by the RCA no take provisions for 9 years. If you were to let this project take place in the RCA, at 250 DBL's, with the documented damage to fish ear bones at lesser sound levels, and with less duration, THEN THERE WOULD BE NO RCA. Furthermore, PG&E has been less than cooperative in any reasonable mitigation process. You can talk to our attorney William Walter, in San Luis Obispo, on this matter. Ironically, he has had experience dealing with oil companies, and fiber optic cable companies on our behalf with no problems. PG&E is the same company that the movie Erin Brockovich is about. If you do not know it, then watch it. If a huge marine mammal and fish kill happens due to this operation, your agency may end up in a new movie. PG&E does not care about us, or our fish stocks. Do you care?

Thank you for your time and consideration on this matter,

Richard Derel Terra
President, Morro Bay Commercial Fisherman's Organization

Dear NOAA/NMFS, P. Michael Payne, October 13, 2012

My name is Benjamin Terra, son of Richard Terra. I have grown up in Morro Bay my whole life, and fished on the ocean for 21 years, 17 of which has been commercial fishing. Commercial fisherman aside, I am writing this letter as a citizen who is extremely concerned with the well being of the local waters off of Avila and Morro Bay. I am also writing on behalf of C.O.A.S.T. (Citizens Opposing Acoustic Seismic Testing). In my 17 years of commercial fishing, I have gotten to intimately know, respect, and love the ocean, to a degree which most people do not have the opportunity. The ocean off of Morro Bay and Avila is so full of amazing life, that almost 9 times out of 10, when I go fishing I see something that I have never seen before, which is hard to believe. I can tell you from my experience, that qualitative time, experience, and observation offers a look into the ocean that quantitative scientific data collection cannot give.

Having fished extensively from Vandenberg Air Force Base up to Año Nuevo Lighthouse, I can tell you that the reef systems specifically from Avila Harbor up to Monterey Bay comprise the most concentrated area of marine biodiversity on the west coast. This is partially due to the extremely rugged and rocky underwater structure not found extensively north, or south of these two points, which creates an amazing amount of habitat. Furthermore, underwater canyons off our local coastline create upwelling that feeds the food chain base with vital nutrients, which are the beginning of a flourishing and extensive marine ecosystem. Finally, this area is nestled above the warmer waters South of Point Conception, and below the more frigid waters North of San Fransisco. Therefore, we have a convergence of species that do not venture further south or north of here, creating an "edge effect." As Toby Hemenway, revered Permaculture scientist explains, in regard to ecological edges: "All the species that thrive in each of the two environments are present, plus new species that live in the biological systems." Considering that the entire West Coast's marine ecosystem gains critical resilience from the edge phenomenon that exists off of the Central Coast, this highly valuable ecological asset is severely threatened by the proposed PG&E seismic testing.

I am shocked that I am even writing this letter because it is so outrageous that the 250-decibel testing would even be considered as a possible option, in light of the 'significant and unavoidable impacts,' to marine life outlined in the California State Lands Commission certified EIR. That EIR, by the way, is a joke in itself, when considering how much critical information was omitted. For example, western gray whales were not even mentioned. The seismic testing from Cambria to Guadalupe would be a total violation of multiple laws that protect our local waters, and done so in complete disregard for the huge amount of work previously put fourth to create those laws. The air cannons blasting at 250 decibels will kill and mortally injure a massive amount of supposedly protected marine life.

250 decibels is the same sound intensity as the atomic bomb that we dropped on Hiroshima: http://www.makeitlouder.com/Decibel%20Level%20Chart.txt. Consider human death is caused at 200 decibels, and that 250 decibels is 32 times louder than the former. Consider that sound travels 5x faster and 25x further in water than it does in air. Take a look at this article posted in SLO Coast Journal of the cumulative decibel levels that will be reached in the Estero Bay:

http://www.slocoastjournal.com/docs/marine_sanctuary.html. PG&E claims that the blasting will not harm marine life. They say that they will "ramp up" the air guns to scare the fish away before reaching 250 decibels. This technique might not work as well as they hope, because I don't think fish can swim faster than the speed of sound. They say the observers on the boats and in the air will make sure no harm is done to marine mammals. However, it has been scientifically documented that only 2% of mortality in the ocean becomes visible on beaches, or floating on the surface. We will not see 98% of what is massacred from the blasting. Furthermore, with blasting taking place 24 hours a day, how will they see anything at night? To illustrate likely effects on local marine life, consider that similar seismic testing done 50 to 80 miles off the coast of Peru was followed by the suspicious deaths of at least 900 dolphins: http://green.blogs.nytimes.com/2012/05/28/expert-links-dolphin-deaths-to-sonar-testing/. The dolphin deaths in Peru are but one of many cases of suspicious mass die-offs of marine life related to seismic testing.

Dolphins are only one of many species of marine mammals that will be affected by 250 decibel air gun blasting. The seismic testing would severely violate the Marine Mammal Protection Act of 1972. As stated on the MMPA fact sheet; http://www.nmfs.noaa.gov/pr/pdfs/mmpa_factsheet.pdf, "The MMPA established a moratorium on the taking of marine mammals in U.S. waters. It defines "take" to mean "to hunt harass, capture, or kill" any marine mammal or attempt to do so. The inclusion of harassment in the definition was a groundbreaking action by Congress." Marine mammals have highly sensitive systems to frequencies and sound waves because of the way that they use them to communicate, navigate and to hunt. The seismic testing would be nothing short of the most horrific method of harassment and murder possible to vibration sensitive marine mammals. NOAA and NMFS would be in violation of your own laws to grant exemptions for PG&E to violate the MMPA.

In regard to killing marine mammals, the seismic testing would also violate the federal Endangered Species Act. It is very clear that the seismic testing would kill anything close to the air guns. Plankton and baitfish largely inhabit the upper water column where the sunlight penetrates. Therefore, the plankton and baitfish could be killed off almost entirely from the testing because of the close proximity to the air guns. Wiping out the lower trophic levels of food from the ecosystem would have disastrous effects on all of the other organisms higher up in the food chain, even if those organisms are not directly killed or injured by the 250-decibel air guns. Southern sea otters would be affected, injured, and killed. Humpback, grey, and western gray whales would be affected, injured, and killed. Great white sharks would be affected, injured, and killed. Brown Pelicans would be affected, starved to death, and forced to vacate our coast, because of food source loss. Aforementioned species are listed as endangered. Should you grant exemptions for PG&E to violate the Endangered Species Act, NOAA and NMFS would be failing to uphold the very laws that were designed to protect these sensitive and essential marine species.

Some of the fish that are protected by way of the Magnuson–Stevens Fishery Conservation and Management Act are considered endangered. The seismic testing would violate that Act, and in turn those endangered fish species. The Rockfish Conservation Area (RCA) prohibits the take of all bottom fish. The RCA has not been touched by sport or commercial fishing for 9 years, and most fishermen would assure you

that there are tens of thousands of pounds of deep water rockfish complex inhabiting it. That massive area of deepwater rockfish stocks includes species such as Boccaccio, Golden Eye, Cow Cod, Vermillion Rockfish, Lingcod, and Canary Rockfish. The seismic testing would devastate thousands upon thousands of protected rockfish in the RCA. Every single fisherman who has fished out of Morro Bay for the last 9 years has personally invested into the RCA by not fishing in it, and NOAA and NMFS would be breaking a treaty with the fishermen by allowing for seismic testing to take place in the RCA.

Considering an allowance to violate the RCA is unacceptable and absurd, considering how serious NOAA is about keeping commercial fishermen from fishing within the closure areas. Consider that since 2008, Vessel Monitoring Systems (VMS) have been required for all commercial vessels that fish for black cod. Black cod fishermen must pay for the VMS, the installation, and the continuous charges accrued for the signal transmission. Aside from tracking them forever after having it installed, the VMS tracks fishermen as they travel through the RCA, out to the black cod fishing grounds, which are out past the RCA. The VMS protocol is required specifically in order to monitor, and to make sure that fishermen do not stop and fish in the RCA.

The fishermen are ultimately assumed guilty until proven innocent, and the VMS protocol is something similar to the ankle bracelet transmitters that criminals are sometimes required to wear. The main difference is that all black cod fishermen are tracked by force, without ever having necessarily violated any law previously. In summary, the VMS protocol shows how serious the intentions are to keep the RCA fish stocks untouched, and protected, even if it means violating Constitutional rights to privacy of U.S. citizens. In light of the stated facts regarding the RCA, it is ridiculous that PG&E would even be considered for an allowance to possibly kill any amount of protected fish stocks, within the RCA, in order to conduct the seismic testing. NOAA and NMFS have a responsibility to the laws you have created and enforced, and you may not grant exemptions for violations of the Magnuson–Stevens Fishery Conservation and Management Act, and the RCA.

Furthermore, let us not forget how sensitive all the fish that dwell in the RCA are to sound waves and vibrations. Similar to marine mammals, fish use vibrations to navigate, hunt, and avoid predation through their lateral lines. All fish have lateral lines, and as stated on the website: http://www.laterallineco.com/fish_lateral_line.html, "A lateral line is a sense organ fish use to detect movement and vibration in the surrounding water. They use it to detect depth/water pressure, prey, and predators, sense current movement and orientation in the current, as well as to avoid collisions. It essentially is a form of eyes, ears and sensory feelings combined into one organ." Even if the blasting does not kill the fish immediately, it will likely cause damage to this organ, resulting in a subsequent and slow death through tissue damage, disorientation, inability to hunt, and loss of food supply.

In summary, I have mentioned three different marine related laws that will be severely violated it the seismic testing is allowed to take place. If NOAA and NMFS were to grant exemptions for seismic testing, it would show a complete lack of integrity within a very agency that is meant to protect our marine resources. Please have integrity, and fulfill your mission statement to our nation. In your own words, you say that you are responsible for the stewardship of the nation's living marine resources and their habitat,

as well as the management, conservation and protection of living marine resources within the United States. You ensure compliance with fisheries regulations and works to reduce wasteful fishing practices. You work with communities on fishery management issues. You promote sustainable fisheries and prevent lost economic potential associated with overfishing, declining species and degraded habitats. Allowing for the seismic testing would be entirely counter productive to your mission statement, which in theory, must be the basis of all decisions you make as an agency. What better way to celebrate the 40th year anniversary of the MMPA, than to show the world, that NOAA and NMFS stand strong to uphold the wonderful protection laws they have gifted to the international community!
Thank you for your consideration

Benjamin Terra

ITP Goldstein <itp.goldstein@noaa.gov>

Oppose PG&E offshore Central California Seismic testing

Bonnie Hale <auntybonbon@comcast.net> Wed, Oct 3, 2012 at 10:37 PM
To: itp.goldstein@noaa.gov
Cc: Glenn_Greenwald@fws.gov

P. Michael Paine
Chief of Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Springs, MD 20910

Dear Mr. Paine,

I am writing as a taxpayer and California resident to vigorously oppose Pacific Gas & Electric's (PG&E) proposed offshore high-energy seismic surveys planned for Diablo Canyon to Cayucos, California.

My family lived in Cayucos, Morro Bay, and San Luis Obispo for five years while my husband was pursuing his undergraduate degree at Cal Poly. One of our chief delights was taking our then young children to the beaches and observing the sea life. That Central California coastline is one of the most beautiful in the world, and migratory path to hundreds of species of marine animals. Morro Bay is also a Marine Protected Area and home to a sleepy fishing village and marsh estuary. The only blight in the area is PG&E's power plant.

In its 2007 *Report to Congress, Marine Mammals and Noise*, the Marine Mammal Commission summarized the potential effects on marine mammals and ecosystems thusly:

"Major human sources of sound include seismic surveys for oil and gas exploration and scientific research; commercial shipping for transportation of goods; and sonar systems for military purposes, fishing, and research. Sound also is important to marine mammals for communication, individual recognition, predator avoidance, prey capture, orientation, navigation, mate selection, and mother-offspring bonding. Potential effects of anthropogenic sounds on marine mammals include physical injury, physiological dysfunction (for example, temporary or permanent loss of hearing sensitivity), behavioral modification (for example, changes in foraging or habitat-use patterns, separation of mother-calf pairs), and masking (that is, inability to detect important sounds due to increased background noise). For individual animals, such effects and their secondary consequences may vary in significance from negligible to fatal—the worst outcome being documented in a small number of cases."

Please tell me how PG&E's proposed noise emissions, which the San Jose Mercury News reports will consist of "very loud blasts of sound--250 decibels-- every 15 seconds nearly continuously for much of November and possibly December," NOT harass or seriously stress the thousands of whales, dolphins, seals, fish, and other sea life in that area? Tell me, too, how the Fisheries Service plans to "protect" and "conserve" these precious natural resources?

PG&E's plan is reckless and to most Californians, the utility company has not proven that it can act responsibly concerning potential risk to life and property.

I request that you to deny PG&E's request.

Sincerely,

Bonnie J. Hale, M.A. Education
P.O. Box 1256
Palo Alto, CA 94302

cc: Fish and Wildlife Service, Guadalupe, CA
The Honorable Anna Eshoo, CA (via webform)

ITP Goldstein <itp.goldstein@noaa.gov>

Seismic testing

Brent Dannells <bdannell@gmail.com> Tue, Oct 16, 2012 at 12:54 AM
To: ITP.Goldstein@noaa.gov

To P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service.

Dear sir, I am extremely concerned about the imminent sonic testing off the Central Coast. My understanding is that P.G. & E. isn't planning to take any action with regards to the seismic testing, so to harass the local marine mammal population seems completely unnecessary. Over the past several centuries we as humans have done too much to deplete the whale and otter populations. The steps we have made the last fifty years have been in the right direction; to allow for this testing would be going in the wrong direction.

Sincerely yours,
Brent Dannells, concerned citizen and Grover Beach resident

ITP Goldstein <itp.goldstein@noaa.gov>

Fw: Re: NOAA Letter

brian stacy <bstacy166@yahoo.com> Tue, Oct 16, 2012 at 2:57 AM
To: ITP.goldstein@noaa.gov

Fishermen members of coast letter. O lost mine in my computer I hope you will except iet in the morning. Brian Stacy V.P. PSLCFA

LETTER TO NMFS.doc
15K

ITP Goldstein <itp.goldstein@noaa.gov>

Port San Luis Commercial Fishermens Association comments on HESS

brian stacy <bstacy166@yahoo.com> Wed, Oct 17, 2012 at 2:02 AM
To: itp.goldstein@noaa.gov

Dear MR. Goldstein, Thank you for the call today and excepting these comments I will forward some of the many emails it took to realize we were in trouble with the low enregy surveys PG&E in general and CSLC as it speaks to integrity of the applicant and CSLC Failures. Which might explain why the EIR is so lame. also I tried to get help from Blakslee as his bill created our mess, NO HELP.

Please tell MR. Payne we would appreciate NOAA takeing a close look at things past and hopefully not future With HESS. .

Port San Luis Commercial Fishermens Associatio2.docx
19K

October 12, 2012

NOAA/NMFS

My name is Richard Derel Terra. I have been working on the ocean since 1974, 38 years, of that time 34 years as a captain. I have studies in Marine Biology. I have held a USCG Master License since passing the exam for the 500 ton Mineral and Oil Master License. My son Ben Terra is a fourth generation of fisherman in our family. My Grandfather worked on the Star of New Zealand which is the sister ship to the Star of India moored in San Diego.

The reason for this letter is in protest of the PG&E's seismic survey of our local waters of San Luis Obispo County. The low level testing had just finished. The vessel was the Pacific Star. Note the vessel A.I.S. System was not on during much of its operation, we have had several porpoise wash up on the beach. I have never seen or heard of this many in my 57 years living in Morro Bay. The Pacific Star's DBL level during their survey was around 135 DBL's. Fisherman locally have noticed a drop in catch, one fisherman who averages 75 pounds to 100 pounds aa day had only 10 pounds for an all day effort.

The high intensity testing is to be 250 DBL's. This with the exponential graduations of the DBL scale will be 4000 times louder than the low level survey. The vessel will be towing 18 air cannon firing every 5 seconds for as of now 12 days. This equals 207,360 blasts, on the Hamby 2004 DBL conversion chart show 248 DBL's to be equivalent to the atomic bomb blasts of Hiroshima and Nagasaki of World War Two. Multiplied by 207,360 times. The vessel will be in depth as shallow as 75 feet with the air cannons 30 feet below the surface. This means there will only be 45 feet between the air cannons a the reefs in it's path, We have many sea mounts in your jurisdiction. The Church Rock area is very abundant with adult fish. Many of these fish are among the endangered and threatened species Bacaccio, Canary, and Yelloweye Rockfish, as we have recent ROV surveys of these areas revealing flourishing abundant reefs.

If you were to permit this project you will be in violation of your own rules as you saw at the Fish & Game meeting on September 24th. PG&E's representative Mark Krauss did not want adult fish kill to be able to stop the project. The fishermen of this area have aboded by the RCA and if you were to let this project to take place in the RCA at 250 DBL's with the documented damage to fish ear bones at lesser levels a less duration. That would mean there is NO RCA. PG&E has been less than cooperative in any reasonable mitigation, you can talk to our attorney William Walter, in San Luis Obispo on this matter. He has had experience dealing with oil companies, and fiber optic cable companies for us with no problems. PG&E is the same company the made the movie Erin Brocovich. If there ends up a huge marine mammal kill and fish kill due to this operation your agency may end up in a new movie. PG&E does not care about us or our fish stocks.

Thank you for your time and consideration on this matter.

Richard Derel Terra
President, Morro Bay Commercial Fisherman's Organization

Port San Luis Commercial Fishermens Association (PSLCFA) Comments on Proposed High Energy Seismic Survey (HESS) off OUR coast

To, NOAA, NMFS

Hello, Thanks you for excepting these comments and I hope you weigh them in when making your decision on the HESS Permit that is before you now. My name is Brian Stacy I am A lifelong resident of Morro Bay (47yrs) I am a 24 year local fisherman I started My career in the shallow water fishery now known as the "Nearshore fishery". I am the current V.P. of PSLCFA, And the past 13 months have been one of the main reps in regard to the unproductive, "NON negotiations" with PG&E in regard to HESS for fisheries displacement and resource damage mitigation. I have been frustrated by PG&Es failure to negotiate in good faith. And have been enlightened about the destructive nature of HESS as we new nothing about 250 DB seismic surveys prior.

We OPPOSE these tests being permitted and conducted and have joined the C.O.A.S.T.. ALLIANCE AND SUPPORT THEIR EFFORT TO STOP HIGH ENERGY SEISMIC SURVEYS HERE.

I will share my experience and knowledge learned through a year and a half of wasted time dealing with this due to PG&E proposing this project, and their unethical buisness practices. All of which was paid for by us as PG&E refuses to even reimburse the associations for legal and consulting fees incured in our review of THEIR project. Not to mention all of our time off work, gas to unproductive meetings, time to prepare and participate in a bogus process were their only intention seems to have been to stall us to this point. Among other expensise all because they proposed this project, that was not mandated by AB 1632 as some might have you believe.. I feel my experience is relavent in your deliberations in regard to this project and any authority or influence you may have to deny a permit or advise others to do so. It should provide you enough insight to understand why they should not be permitted to do HESS at this time or Hopefully ever and why they should not have already been allowed to do LESS (low energy seismic surveys).

I will first touch on LESS and the problems with it as it did not go through a CEQA process as it should of and there was no EIR or current MND to go with this project that was conducted around protected areas like the RCA, MPA and under the MLPA. None of which are reffrenced in the environmental document they (PG&Es contractor Fugro) were allowed to use under the CSLC outdated Geophisical Survey Permit Program (GSPP). there was also no mention of current fisheries we utilize like hagfish and nearshore the ones that were directly impacted by LESS Although totally inappropriate and outdated they did not even comply with the mitigation measures outlined in the 1984 MND 358 and GSPP that CSLC issued their "umbrella" permit

under. Further CSLC refused to except complaints on or do monitoring after complaints were made, or enforcement any of the inappropriate mitigation measures that were outlined in the two outdated documents, And they refuse to recognize the update, "guidelines to reduce conflicts between "geophisical surveys and fishermen", that was produced by Fishermen and oil companies in 1989 through the "Joint Oil Fisheries Liason Committee" in response to problems that had arisen after the 1984 program was introduced and implimented. This is all relavent because you are reviewing a document The HESS EIR that was produced by the same entity and full of inadequacies and unmitigated impacts. I thought you might like to know of the LESS situation in regard to CSLC and the project applicant, as I made Both aware of the problems, and view your recommendation on HESS to CCC through it.

The problems that arose from this what I believe to be Illegal survey due to our rights under CEQA not having been provided to us by CSLC Staff are as follows. First to my area the Nearshore fish suffered from mortality issues (abnormal amount dying in the tank) and the catch was down by 50% in port san luis, and there was behavioral issues as well alot were found to be weak. The halibut trawlers catch dropped off to near nothing the Hagfish fishermen were displaced as well and their catch was down 50% too. All of this happened after LESS showed up unannounced. There was displacement of fishing effort by the survey vessel and noise issues as far as catching fish. The whales and bait left after the last LESS showed up unannounced creating a tourism impact to avila and the harbor and there were others as well i am too slow of typer to outline here. None of these were Identified before they happened or mitigated after. Had we been provided our due process under CEQA we would have fought for all of these to be fully addressed, studied and mitigated as needed. Alongside other california residents.

As far as the fishermen I represent go I registered a complaint with the HESS applicant PG&E and they said "it was not their permit" But that they were "prepared to compensate the displacement of fishermen" only. They gave me a "refrigerator claim form" (fridge form) the type they give out if the power goes out and there is "food spoilage". They also said they were going to pay the claims which they later rejected after stalling until that survey was over. And they had told me to pass them out to effected fishermen and I did. I indicated to them it was not a "fishing type of claim form" and that we should have had meetings and negotiated a process for claims, and forms qualifying criteria ect.and asked where they prepared to do that now? they refused to discuss it as it was not their permit they said. I asked "how did your contractor get a permit without us having a chance to review and comment and negotiate for fair mitigation for my fishermen and to identify impacts on our resources and get agreements in place to mitigate all the above. They indicated talk to FUGRO it is their permit. This all happened after 12-4-11 when the unannounced 20 day LESS began. and the hell that has been my life since was put upon me by PG&E the project applicant. This all happened on the heels of HESS negotiations beginning and we have achieved nothing in regard to those . this story is long

and sad as it has taken over the place that used to be my life~! I have many email exchanges if you need to see how pathetic PG&Es treatment of the fishermen they displace with their surveys and their utter disregard for our rights as established buisnesses and our permits to catch fish and right to make a living. And the same can be said for their concern for the resource they will further disrupt should HESS be permitted and allowed to be conducted in the same general area which I really hope it is not.

Beyond the CEQA violations and the failure to enforce mitigation measures the fishery related issues the overall resource issues, the compliance issues the data poor issues the failure to address MLPA, MPA, RCA issues the no compensation issues the no agreements issues the noise related issues the NO CURRENT ENVIRONMENTAL ASSESMENT OR DOCUMENT pertinant in todays regulatory environment issues The applicable fisheries issues there lies and this goes back to our rights to review in a situation like this under CEQA the no baseline data issue.

As fishermen we have a pretty good knowledge of our local ocean resources and how they could be effected by different events that happen in the ocean environment, from a "EL NINO" event to what our concerns would be with a "LESS" and most things in between. My personnel feeling about the worst thing from the LESS being conducted without review is that we lost a golden oppertunity to collect data prior to these I believe Illegal surveys beginning. As we did with HESS we the fishermen would have called for a current baseline of data to be gathered so we could identify impacts after the LESS. now I see that could have been applied to the HESS as well. The LESS has already had impacts on the resources we may never be able to know for sure what they are. Derel reffrenced the dead dolphin thing and I was told they did not do mammal monitoring at all .so we do not know what kind of harrasment the whales and dolphins may have had bestowed on them or if they were injured or killed as with no mammal monitoring as outlined in that old mnd they used we will never know.

I think the main points I want to make are the Lack of regard for OUR CEQA rights, potential impacts to the resource, the fishermen and our families, by CSLC staff that told me last week was because "they are to broke to provide public process and produce a new environmental document for LESS". I have no idea why they should have to with old PG&Es contractor applying. And. they also refused to allow a complaint on my second attempt as well and refused to do any enforcement too. they indicated the contractor Fugro had "complied with all mitigation measures" because they said "fugro told us they had" even though I was offering evidence to the opposite they refused to take a complait or do anything at all. They did say that currently PG&E is working on a new MND for LESS so maybe I accomplished something. But it makes you wander "why not before they began LESS"? I neglected to mention that Richard Greenwood the CSLC staff member in charge of these surveys was unable to produce a copy of mnd 358 or the GSPP that he was giving permits out based on when I requested it and I had to

get it elsewere in CSLC and it was not on the websight either. and is the guy I made 2 formal complaints to on LESS that took NO action and refused to either take a complaint or monitor for compliance after I MADE THE FIRST ONE ONLY ALLOWED THEM TO GO ON. This is the people that developed the inadequate EIR that is lacking in so many areas that you are preparing to make a decision based on. Has anyone seen the section on the western grey whale?

Lessons learned through this process: or lack thereof:

1. PG&E cannot be trusted. not with a valuable resource like our central CA. ocean. They can not be trusted to compensate effected buisnesses and municipalities or anybody impacted by their operations anywhere look at the poor folks in San Bruno and others.

2. CSLC will overlook any violation and do not understand the words mitigation, enforcement, monitoring,. compliance,, complaint, process, and a few others or CEQA either. If we would have had a time machine maybe but shy of that we had no way or oppertunity to comment. And the current EIR for HESS would need a substantial upgrade to be inadequate I was being kind.!

I have others but I would seem like I resent this HESS process and LESS issues eating up so much of my life because I volunteered to be abused by PG&E when I first allowed myself to be elected "Nearshore fishermens representative" And later when I allowed myself to be elected V.P. of PSLCFA and become lead on this Issue to protect my fellow fishermen and for us to try to stop this kind of thing from happening with HESS should regulators not do the right thing and deny the permit and reject this destructive and intrusive unmandated project.

Thank You for your time and conscideration in regard to this matter. Should anyone want anything like email chaiin a copy of the fridge form ect. I am includeing a couple in regard to the complaints to CSLC and the lie by PG&E about paying the clams and i may see others that i should send too!

Brian Stacy Vice President Port San Luis Commercial Fishermens Association

PSLCFA is A member of the C.O.A.S.T. Alliance and supports their efforts to stop permitting of this project and the project itself for the sake of our local resources!

ITP Goldstein <itp.goldstein@noaa.gov>

you can do this..

brother light <floweroflifebypleiadian@gmail.com> Mon, Oct 15, 2012 at 8:46 AM
To: ITP.Goldstein@noaa.gov

are you crazy americans to do this ...i hope is not true why you want to kill so many fish in the ocean???
this is no a human we need live in peace whit all !!!!

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Stop Diablo Canyon Nuclear Plant Seismic Testing

Howard Goldstein <howard.goldstein@noaa.gov> Tue, Oct 16, 2012 at 9:07 AM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Coming Alive! with Camille** <camille@camillesheart.com>
Date: Tue, Oct 16, 2012 at 2:25 AM
Subject: Stop Diablo Canyon Nuclear Plant Seismic Testing
To: howard.goldstein@noaa.gov

Dear Mr. Goldstein,

I am writing to ask that you do what is possible to STOP Diablo Canyon seismic testing. The California Fish & Game Commission derided the project as ecologically risky and scientifically unnecessary and the Natural Resources Defense Council (NRDC) now say the project would create environmental devastation with no clear benefit. As PG&E has stated they will make no plant upgrades regardless of the seismic results, seismic testing does nothing to improve our safety.
The testing further endangers our whales and this area being the core home of the species, Harbor Porpoises and Otters could be rendered completely extinct if this unnecessary seismic testing is allowed to go forward.

Please help protect our marine mammals!

Sincerely,

Camille Yoshiko & Rick Copeland

==========

MAY THE LIGHT OF GOD BE WITH US

AND HELP US BECOME

SWEETER HUMAN BEINGS

AND REAL FRIENDS TO ALL PEOPLE

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries

Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

NOAA FISHERIES

ITP Goldstein <itp.goldstein@noaa.gov>

Comment Letter on PG&E Proposed IHA permit

Carol Georgi <cdgeorgi@hotmail.com> Sun, Oct 14, 2012 at 4:05 PM
To: "ITP.Goldstein@NOAA.gov" <itp.goldstein@noaa.gov>
Cc: "cassidy.teufel@coastal.ca.gov" <cassidy.teufel@coastal.ca.gov>, "fmecham@co.slo.ca.us" <fmecham@co.slo.ca.us>, "bgibson@co.slo.ca.us" <bgibson@co.slo.ca.us>, adam hill <ahill@co.slo.ca.us>, "pteixeira@co.slo.ca.us" <pteixeira@co.slo.ca.us>, "jpatterson@co.slo.ca.us" <jpatterson@co.slo.ca.us>

October 14, 2012

P. Michael Payne, Chief

Permits and Conservation Division

Office of Protected Resources

National Marine Fisheries Service

1315 East-West Highway, Silver Spring, MD 20910

Sent by email c/o ITP.Goldstein@NOAA.gov

RE: PG&E application for an IHA to take Marine Mammals Incidental to Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Dear Mr. Payne:

Please find attached to this email:

Comment Letter on PG&E Proposed IHA permit

Cumulative SEL Modeling Airguns, Box 4 diagram from PG&E's EIR

Environmental Impacts Seismic Survey article by NRDC

Thank you,

Sincerely,

Carol Georgi

Coordinator of California Central Coast Marine Sanctuary Alliance

243 Vista Del Mar

Pismo Beach, CA 93449

cdgeorgi@hotmail.com

---

3 attachments

box 4 sound cumulation.jpg
323K

MSA letter to NMFS.doc....doc
374K

Environmental Impacts of Seismic Surveys.pdf
175K

October 14, 2012

P. Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway, Silver Spring, MD 20910
Sent by email c/o ITP.Goldstein@NOAA.gov

RE: PG&E application for an IHA to take Marine Mammals Incidental to Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Dear Mr. Payne:

As the Coordinator of the California Central Coast Marine Sanctuary Alliance, I am writing to comment on four vital omissions to the National Science Foundation (NSF) Draft Environmental Assessment (EA) that without consideration would result in serious harm to marine mammals, humans, and the marine ecosystem.

Based on review of the project description and scientific studies, the project is not eligible for an Incidental Harassment Authorization pursuant to the Marine Mammal Protection Act (MMPA), because impacts will not be limited to Level B harassment of marine mammals, but will in fact result in significant *Level A* take of marine mammals.

First, the state and federal environmental analyses have inconsistencies and have come to different conclusions as to the degree of significant and unavoidable impacts the proposed project will cause.

What key information does the NSF have that reduces the probable impacts to mammals to only Level B harassment?

Second, the proposed mitigations are insufficient to adequately protect the mammals for only Level B harassment. Since the high intensity air gun blasting will occur during night, no amount of lights or

goggles will be sufficient to see the whales, and Level A harassment would most likely occur.

Please consider and add the following research statements to the environmental assessments.

Lindy Weilgart Research Associate, Department of Biology, Dalhousie University, Halifax, Nova Scotia, Canada. E-mail: Linda.Weilgart@dal.ca

The January-February 2010 MPA News article http://depts.washington.edu/mpanews/MPA112.htm

3. Mitigation measures such as safety zones, ramp-ups, etc. can be imperfect, even inadequate, in protecting whales from harm. Most are based on little to no scientific evidence, such as that whales will avoid airguns [which produce the sound waves used in seismic surveys]. If airguns stun whale prey, for instance, whales may be attracted to the survey area, even to the detriment of their hearing.

4. While I applaud the stricter mitigation measures in the case of the Endeavour Hydrothermal Vents MPA, a 7-km radius of safety zone is very difficult to monitor practically for whales.

Third, both environmental assessments do not consider using alternative seismic testing technologies and/or less intensity air gun decibel blasts for highly sensitive mammals. Newer scientific research indicates the “safe” received decibel level for most mammals is not 160 dB or higher, but in fact 130 dB.

Therefore, a seismic survey that persists in using the former 160 dB or higher received decibel level is ignoring current research and will result in Level A take of mammals. Please consider and add the following research statements to the environmental assessments.

Lindy Weilgart Research Associate, Department of Biology, Dalhousie University, Halifax, Nova Scotia, Canada. E-mail: Linda.Weilgart@dal.ca

The November-December 2009 MPA News article (*MPA News* 11:3) on seismic surveys and MPAs resulted in a letter from Lindy Weilgart,

PhD stating that “whale and fish disturbance is well documented at receive levels of 130 decibels (dB) and below—in contrast to the 160-dB threshold used at Endeavour, which is 1,000 times louder.”

“It is time to seriously research and promote more benign airgun alternatives such as, perhaps, controlled sources, passive seismic [the detection of natural low-frequency earth movements], electromagnetic surveys, etc. - especially in sensitive habitats.”

Jim Cummings Executive Director, The Acoustic Ecology Institute, Santa Fe, New Mexico, US. E-mail: jim@acousticecology.org; Web: AcousticEcology.org

The January-February 2010 MPA News article http://depts.washington.edu/mpanews/MPA112.htm

“The 160-dB "safe" criterion noted in the article and widely used in mitigation plans likely represents roughly the sound level at which half the population will be expected to change its behavior in noticeable ways. Unfortunately, the correlation between sound level and behavioral disruption is not at all linear. Many individuals (and some species, particularly harbor porpoises and beluga whales) respond with aversion or foraging disruptions at much lower levels, down to 120dB. There will always be a subset of a population that is more sensitive to noise.”

Therefore, the received decibel level for harbor porpoises and beluga whales needs to be no more than 120 dB. This lower decibel level is especially important for the Morro Bay harbor porpoises because they will receive Level A Harassment unless the project lowers the received decibel level to 120 dB.

Fourth, both the state’s EIR and the federal EA do not provide a safety zone for humans. The intense decibel blasts travel to shoreline where the ocean is full of people swimming and surfing. Establishing a safe zone for humans is essential before deciding the intensity of the air gun blasts in a seismic testing project.

The environmental assessments must adequately address the harm the high intensity decibel air gun blasts could cause to humans recreating in the ocean. Both environmental assessments need to determine the safe received decibel level for humans, and then

provide the necessary safety zone from shoreline out at least two miles.

What is the safe received decibel level that will cause no harm to humans recreating in the ocean?

In order to assess the impacts to humans and to marine ecosystems, the EIR and the EA need to provide analysis and description of the decibel level beginning at source of array of air gun blast, how far and at what magnitude the acoustic pulses will travel, and at what decibel level will be received at various locations.

Please provide complete description and detail of the acoustic pulse wave so there is understanding that the shock wave adversely affects more than hearing, for example, soft tissue, air sacks, bladders, lungs, etc.

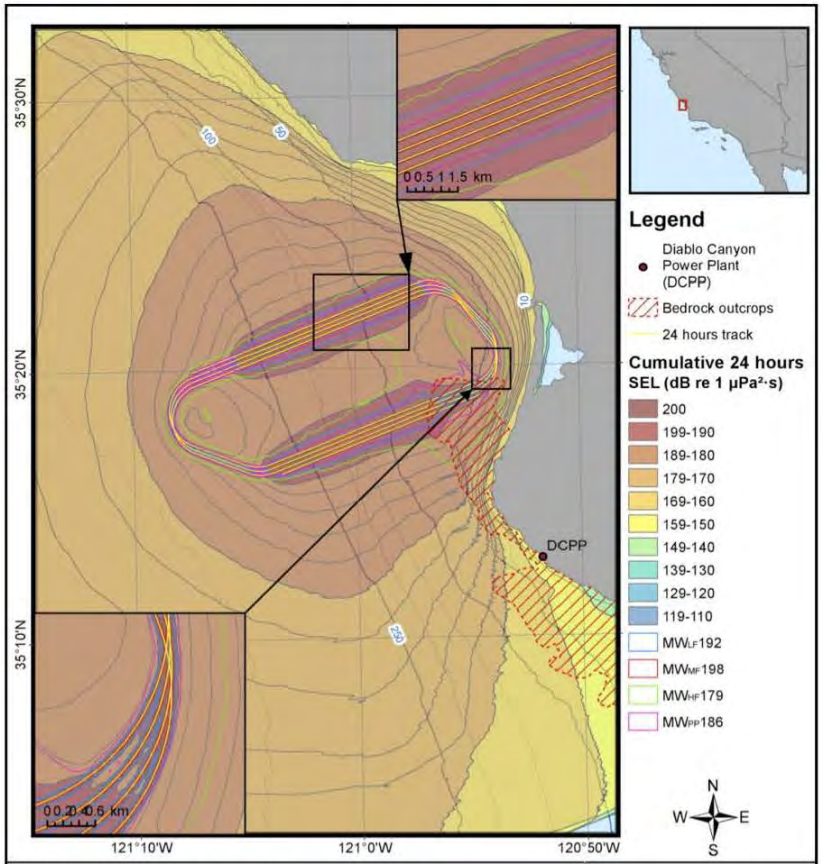
PG&E's EIR states seismic testing can impact humans:

"The proposed offshore activities *would* expose persons present in the water to harmful noise levels..."

"Studies have shown that high levels of underwater noise can cause dizziness, hearing damage, or other sensitive organ damage to divers and swimmers, as well as indirect injury due to startle responses"

"Noise levels in excess of 154 dB re 1 μPa could be considered potentially harmful to recreational divers *and swimmers* in the Project area".

This map, from the EIR, of the proposed cumulative sound in Box 4, Estero Bay, shows that decibel levels could reach over 160 dB at some beaches. This is well over the threshold for human safety. The Marine Sanctuary Alliance is troubled by PG&E's apparent disregard for the health and safety of ocean users.



Description: Cumulative SEL Modeling Results: Airguns, SBP, and MBES at Box 4

0 2.5 5 10 km

Project: Offshore Central Coast Seismic Imaging Project

Projection: UTM Zone 10 **Datum:** WGS 1984

Created By: Mikhail Zykov

Date: 10 February 2012

JASCO APPLIED SCIENCES

In addition, Low level acoustic seismic testing has been occurring along the CA Central Coast by PG&E using the *Pacific Star* and an old 1984 permit from CA State Lands Commission, and evidently not having a permit from the CA Coastal Commission, nor the federal agencies. CA law AB1632 requires PG&E to review the current studies and does not mandate high intensity acoustic seismic testing.

Thank you for your attention to these comments. The proposed PG&E Central Coast Acoustic Seismic Imaging Project does not qualify for an IHA permit. Granting the permit would result in Level A harassment to mammals, especially harbor porpoises, and serious harm to humans and the marine ecosystem.

Sincerely,

Carol Georgi

Coordinator of California Central Coast Marine Sanctuary Alliance
243 Vista Del Mar
Pismo Beach, CA 93449
cdgeorgi@hotmail.com

cc

Cassidy Teufel
California Coastal Commission
Energy, Ocean Resources and
Federal Consistency Division
Cassidy.Teufel@coastal.ca.gov

San Luis Obispo Country Board of Supervisors
District 1 Frank Mecham
fmecham@co.slo.ca.us
District 2 Bruce Gibson
bgibson@co.slo.ca.us
District 3 Adam Hill
ahill@co.slo.ca.us
District 4 Paul Teixeira
pteixeira@co.slo.ca.us
District 5 James Patterson
jpatterson@co.slo.ca.us

Ocean Facts

© Erin Falcone/www.cascadiaresearch.org

Boom, Baby, Boom:
The Environmental Impacts of Seismic Surveys

For offshore exploration, the oil and gas industry typically relies on arrays of airguns, which are towed behind ships and release intense impulses of compressed air into the water about once every 10 to 12 seconds. Although most of the energy from these acoustic "shots" is intended to search downward for evidence of oil and gas deep beneath the seafloor, a significant amount of the energy travels outwards and can be heard throughout vast areas of the ocean. The environmental problems created by these noise invasions are not fully understood, but we do know that these intense sounds threaten the habitats of endangered whales and commercial fisheries, and cannot remotely be confined to the waters off individual states that approve offshore production. Seismic surveys have been shown to disrupt essential behavior in endangered whales and cause catch rates of some commercial fish to plummet—in some cases over enormous areas of ocean. To mitigate these impacts, NRDC recommends that airguns be kept out of sensitive areas and that greener alternatives be promoted, some of which are already well into development and could be made commercially available within a few years.

For more information, please contact
Michael Jasny
(604) 736-9386

NRDC
The Earth's Best Defense

www.nrdc.org/policy

Airguns and Ocean Life

The ocean is an acoustic world. Unlike light, sound travels extremely efficiently in seawater, and marine mammals and many fish depend on sound for finding mates, foraging, avoiding predators, navigating, and communicating—in short, for virtually every vital life function. When we introduce loud sounds into the ocean, we degrade this essential part of the environment. Some biologists have likened the increasing levels of noise from human activities to a rising tide of "smog" that has urbanized and in some areas industrialized major portions of the marine environment off our coasts. This "acoustic smog" is shrinking the sensory range of marine animals.[1] A substantial and growing body of research now indicates that ocean noise pollution negatively affects at least 55 marine species, including several endangered species of whales and 20 commercially valuable species of fish.[2,3]

Seismic surveys have a staggering environmental footprint. A large seismic array can produce peak pressures of sound higher than those of virtually any other man-made source

Boom, Baby, Boom:
The Environmental Impacts of Seismic Surveys

save explosives;[4] and though its airguns are pointed downwards towards the sea floor, their sound travels outward so widely as to significantly raise noise levels literally thousands of miles away.[5] The director of Cornell's Bioacoustics Research Program once described these surveys as possibly **"the most severe acoustic insult to the marine environment."** Unfortunately for the whales, airgun surveys last anywhere from weeks to many months and, in many coastal areas that represent vital feeding and breeding grounds, cause animals harm by depriving them access to their normal acoustic habitats.

Impacts on a Population Scale

The impacts of seismic surveys are felt on an extraordinarily wide geographic scale. For example, a single seismic survey can cause endangered fin and humpback whales to stop vocalizing—a behavior essential to breeding and foraging—over an area *at least* 100,000 *square nautical miles in size*.[6,7] The few animals that persist in calling seem to abandon the entire area, which is larger than the state of New Mexico. Seismic surveys can also drown out mating and other calls of endangered whales over enormous distances. Beyond several miles, the periodic blasts of airguns can sound virtually continuous, making it impossible for species that use low-frequency sound— like the endangered great whales—to communicate, feed, and find mates.[8,9]

Alarmingly, one of the species most vulnerable to these impacts, according to the latest research from NOAA and Cornell, is the critically endangered North Atlantic right whale, whose only known calving grounds occur off Florida and Georgia.[10,11]

Given the scales involved, surveys taking place off the coast of Virginia could well affect endangered species off southern New England, and right whales could be disrupted throughout their east-coast migratory range.

Airguns have also been shown to affect a broad range of other marine mammal species beyond the endangered great whales. For example, sperm whale foraging appears to decline significantly on exposure to even moderate levels of airgun noise;[12] and harbor porpoises have been seen to engage in strong avoidance responses fifty miles from an array.[13] Seismic surveys have been implicated in the long-term loss of marine mammal biodiversity off the coast of Brazil.[14]

Impacts on Fish and Fisheries

Airgun surveys also have serious consequences for the health of fisheries. For example, airguns have been shown to dramatically depress catch rates of various commercial species (by 40 to 80 percent) over thousands of square kilometers around a single array,[15,16] leading fishermen in some parts of the world to seek industry compensation for their losses. These compensations are already occurring

The Seismic Footprint
Noise from a single seismic survey, operating in the direction of the upper right corner, saturates an area in the North Atlantic larger than the state of West Virginia (10,000 square nautical miles), masking low frequencies used by endangered baleen whales. Red signifies noise several orders of magnitude higher than the prevailing background noise in the region. In fact, biologists have found that airguns cause endangered fin and humpback whales to go silent over an area at least 10 times larger than this.

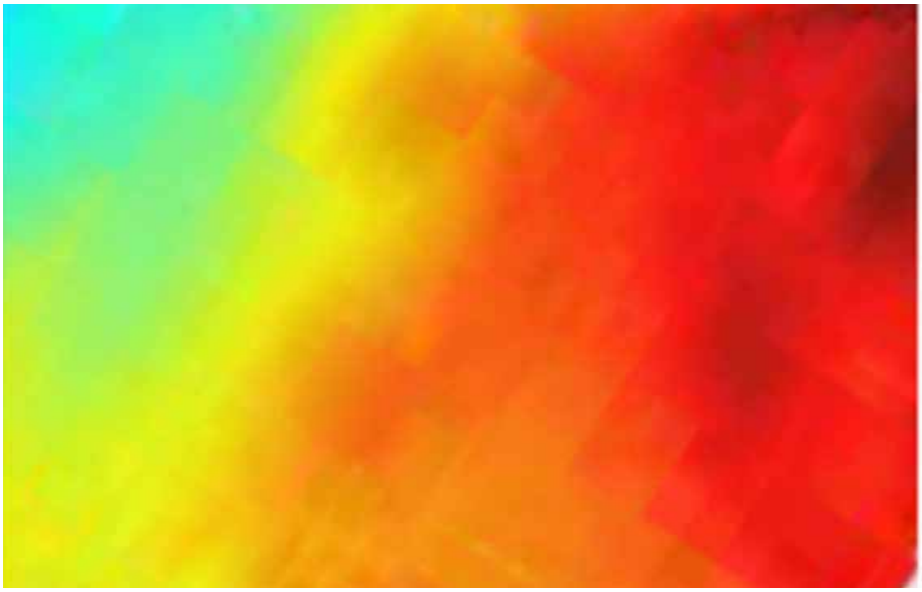


Image credit: Clark and Gagnon, 2006.

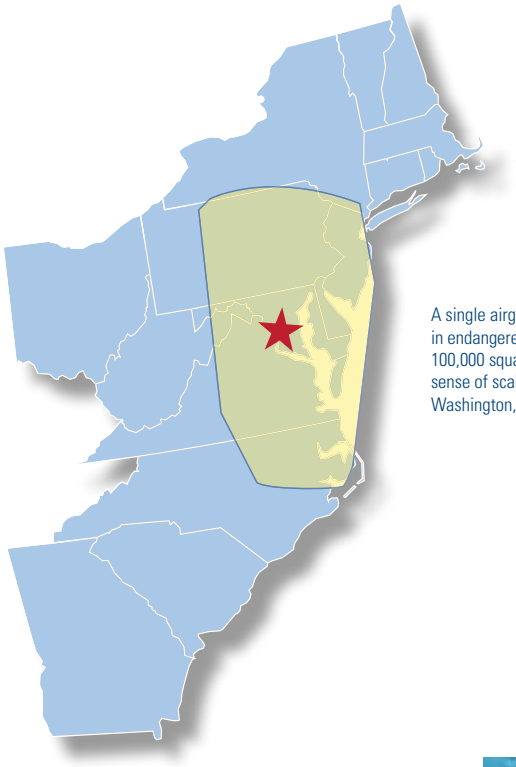
in Norway. Other impacts on commercially harvested fish include habitat abandonment—one possible explanation for the fallen catch rates—reduced reproductive performance, and hearing loss;[17-19] and recent data suggest that loud, low-frequency sound also disrupts chorusing in black drum fish, a behavior essential to breeding in this commercial species.[20]

What's in Store for the Atlantic

How much seismic surveying are we likely to see in the former moratorium areas? Within months after the Minerals Management Service (MMS) issued its scoping notice for the Atlantic region, Spectrum Geo proposed shooting 112,500 line miles of surveys from Massachusetts down to Florida, Western Geco another 54,900 miles between New Jersey and Georgia, and CGG Veritas more than 42,000 miles running southwards from Maine. In all, more than 285,000 line miles were proposed in the initial flurry of applications.[21] Industry will conduct more surveys as areas are opened for leasing, and will send ships back time and again to certain areas of interest to see how geologic features there change over time. On top of this, some companies are making more and more use of "wide azimuth" surveys, in which up to four airgun arrays run side-by-side and fire in tandem.

The Way Forward

The mitigation measures typically prescribed by MMS require little more than visual monitoring for marine mammals within a small "safety zone" immediately around the seismic vessel. But that approach is completely inadequate to redress the large-scale environmental harm that science has identified.[22] The only effective ways to mitigate these serious longer-range impacts are to keep airguns out of sensitive environmental areas (and the areas nearby), to cap the number of activities allowed each year by region, to bar redundant surveys, and to promote the use of greener alternatives—some of which are already well into development and could be made commercially available within a few years.



A single airgun array can disrupt vital behavior in endangered whales over an area at *least* 100,000 square nautical miles in size. For a sense of scale, here is that area centered over Washington, D.C.

NRDC makes the following recommendations:

- **Congress should not introduce new "seismic inventory" language into the pending climate and energy bills.**

  A provision in the Senate's energy bill would mandate that MMS conduct a seismic inventory of the OCS and authorize more than $750 million for the purpose. In addition to unnecessarily subsidizing the industry, such a provision would result in significant environmental harm to marine mammal and fish habitat in regions, like the northeast and west coasts, that strongly oppose OCS development on environmental grounds and will certainly not figure in any government lease plan for at least 7 years.

- **Congress should strengthen environmental review of seismic surveys on the Outer Continental Shelf.**

  Allowing airgun surveys to proceed across ocean regions without even considering their harmful impacts, and how to mitigate them, is simply irresponsible and could result in needless harm to commercial fisheries and endangered species on a wide scale. Yet in some regions, like the Gulf of Mexico, neither MMS nor industry have obtained legally required permits under the Marine Mammal Protection Act or satisfied environmental review requirements of other laws. As one important step, Congress

©www.flickr.com/joachim_s_mueller

Atlantic cod

©www.flickr.com/joachim_s_mueller

Haddock

should amend the Outer Continental Shelf Lands Act to let the public seek judicial redress against companies that violate the Marine Mammal Protection Act.

- **Congress should authorize research and development funding for lower-impact exploration technologies and require MMS, in consultation with NOAA, to set 5- and 10-year benchmarks for their development and use.**

© NOAA

North atlantic right whale

According to industry experts, airguns produce a great deal of "waste" sound and generate peak levels (which are thought to be one of the dangerous characteristics of airgun noise) substantially higher than those actually needed for exploration. Lower-impact technologies that would substantially shrink the environmental footprint of airguns in many areas could be available for commercial use within 3 to 5 years. Marine vibrators, for example, have the potential to reduce peak sound levels by 30 to 50 decibels, at least in shallow water, turning an extraordinarily powerful airgun array into the equivalent of a very large ship.[23] But increased funding and regulatory involvement are essential to realizing these lower-impact alternatives.[24]

1,2 Bode, M., Clark, C.W., Cooke, J., Crowder, L.B., Deak, T., Green, J.E., Greig, L., Hildebrand, J., Kappel, C., Kroeker, K.J., Loseto, L.L., Mangel, M., Ramasco, J.J., Reeves, R.R., Suydam, R., Weilgart, L. 2009. Statement to President Barack Obama of Participants of the Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals. 2pp. E.g., Hildebrand, J.A. 2005. Impacts of anthropogenic sound. In: Reynolds, J.E., et al. (eds), Marine Mammal Research: Conservation beyond Crisis. Baltimore: Johns Hopkins University Press. 23pp.

3 E.g.,Weilgart, L. (2007). The impacts of anthropogenic ocean noise on cetaceans and implications for management. Canadian Journal of Zoology 85: 1091-1116.

4 National Research Council (NRC). 2003. Ocean Noise and Marine Mammals. Washington: National Academy Press. 204 pp.

5 Nieukirk, S.L., Stafford, K.M., Mellinger, D.K., Dziak, R.P., and Fox, C.G. (2004). Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean. Journal of the Acoustical Society of America 115: 1832-1843.

6 Clark, C.W., and Gagnon, G.C. (2006). Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales. IWC/SC/58/E9. Submitted to Scientific Committee, International Whaling Commission. 9pp.

7,20 Clark, C.W. personal communication.

8,10 Clark, C.W., Ellison, W.T., Southall, B.L., Hatch, L., van Parijs, S., Frankel, A., Ponirakis, D. (2009a). Acoustic masking in marine ecosystems as a function of anthropogenic sound sources. IWC/SC/61/E10. Submitted to Scientific Committee, International Whaling Commission. 19pp.

9,24 Weilgart, L. ed. (2010). Report of the workshop on alternative technologies to seismic airgun surveys for oil and gas exploration and their potential for reducing impacts on marine mammals, 31 Aug. – 1 Sept., 2009, Monterey, Calif. Darmstadt: Okeanos – Foundation for the Sea. 35pp.

11 Clark, C.W., Ellison, W.T., Southall, B.L., Hatch, L., Van Parijs, S.M., Frankel, A., and Ponirakis, D. (2009b). Acoustic masking in marine ecosystems: Intuitions, analysis, and implication. Marine Ecology Progress Series 395: 201-222.

12 Miller, P.J.O., Johnson, M.P., Madsen, P.T., Biassoni, N., Quero, M., and Tyack, P.L. (2009). Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. Deep-Sea Research I 56: 1168-1181.

13 Bain, D.E., and Williams, R. (2006). Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance. IWC/SC/58/E35. Submitted to Scientific Committee, International Whaling Commission. 13pp.

14 Parente, C.L., Pauline de Araújo, J., and Elisabeth de Araújo, M. (2007). Diversity of cetaceans as tool in monitoring environmental impacts of seismic surveys. Biota Neotropica 7(1).

15 Engås, A., Løkkeborg, S., Ona, E., and Soldal, A.V. (1996). Effects of seismic shooting on local abundance and catch rates of cod (Gadus morhua) and haddock (Melanogrammus aeglefinus). Canadian Journal of Fisheries and Aquatic Sciences 53: 2238-2249.

16 Skalski, J.R., Pearson, W.H., and Malme, C.I. (1992). Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (Sebastes ssp.). Canadian Journal of Fisheries and Aquatic Sciences 49: 1357-1365.

17-19 E.g., McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, C., Jenner, M.-N., Penrose, J.D., Prince, R.I.T., Adhitya, A., Murdoch, J. and McCabe, K. (2000). Marine seismic surveys: analysis and propagation of air-gun signals, and effects of air-gun exposure on humpback whales, sea turtles, fishes, and squid. Western Australia: Curtin U. of Technology. 203pp. McCauley, R., Fewtrell, J., and Popper, A.N. (2003). High intensity anthropogenic sound damages fish ears. Journal of the Acoustical Society of America 113: 638-642. Scholik, A.R., and Yan, H.Y. (2002). Effects of boat engine noise on the auditory sensitivity of the fathead minnow, Pimephales promelas. Environmental Biology of Fishes 63: 203-209..

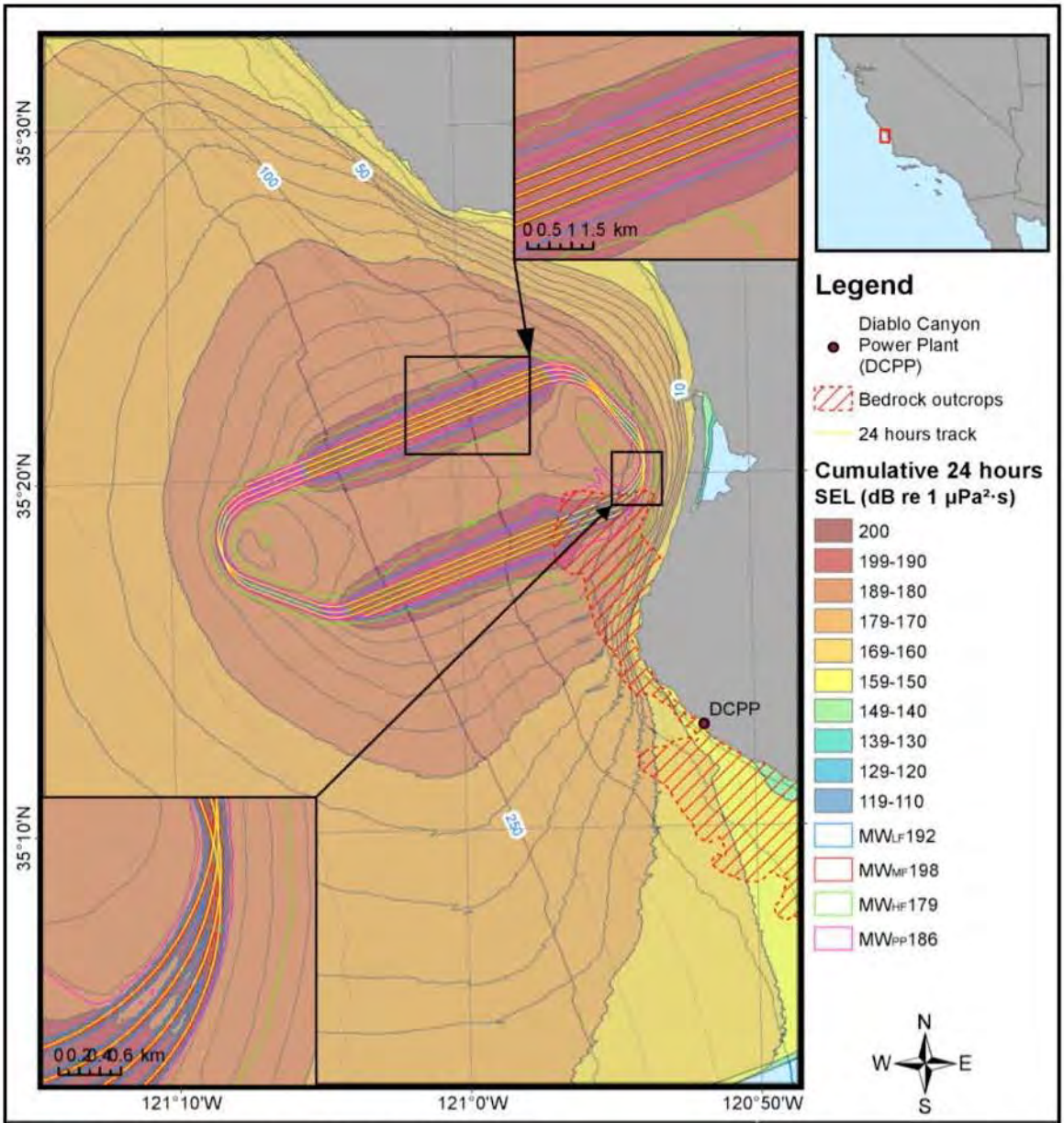
21 MMS. (2010). Atlantic Geological and Geophysical (G&G) Activities Programmatic Environmental Impact Statement (PEIS). Available at www.gomr.mms.gov/homepg/offshore/atlocs/gandg.html. Accessed May 17, 2010.

22 Parsons, E.C.M., Dolman, S.J., Jasny, M., Rose, N.A., Simmonds, M.P., and Wright, A.J. (2009). A critique of the UK's JNCC seismic survey guidelines for minimising acoustic disturbance to marine mammals: Best practice? Marine Pollution Bulletin 58: 643-651.

23 Weilgart, L. ed. (2010). See also Spence, J., Fischer, R., Bahtiarian, M., Boroditsky, L., Jones, N., and Dempsey, R. (2007). Review of existing and future potential treatments for reducing underwater sound from oil and gas industry activities. Billerica, Mass.: Noise Control Engineering. 193pp.

© Natural Resources Defense Council May 2010

Printed on recycled paper



Description: Cumulative SEL Modeling Results: Airguns, SBP, and MBES at Box 4

km 0 2.5 5 10

Project: Offshore Central Coast Seismic Imaging Project

Projection: UTM Zone 10 **Datum:** WGS 1984

Created By: Mikhail Zykov

Date: 10 February 2012

JASCO APPLIED SCIENCES

ITP Goldstein <itp.goldstein@noaa.gov>

INCIDENTAL HARRASSMENT

cecilep@att.net <cecilep@att.net> Fri, Sep 21, 2012 at 7:02 PM
To: ITP.Goldstein@noaa.gov

To: P. Michael Payne:

Subj: "incidental harrassment" causing payne to marine life

Dear Mr. Payne:

The purpose of conducting seismic studies by the Lamont Doherty Earth Observatory is to map the seismic faults along the california coast in connection with the proximate location of two nuclear installations: san luis obispo diablo canyon; and san clemente san onofre.

it might be a better idea to decommission both nuclear plants (one of them is likely never again to re-start, havingf the absolute worst safety record of all 104 other us nuclear plants; that leaves san luis obispo. wouldn't it be better to shut plants down rather than indiscriminately slaughter a whole bunch of marine mammals which have just as much right to life as humans?

cecile pineda
Author of *Devil's Tango: How I Learned the Fukushima Step by Step*
available from Wingspress.com

"Repeatedly expecting a sane response from those who are insane is an exercise in madness." -Paraphrasing Einstein

ITP Goldstein <itp.goldstein@noaa.gov>

No to Seismic Exploration near Diablo Nuclear Power Plant

charmaine coimbra <cmcoim@msn.com>
To: itp.goldstein@noaa.gov

Fri, Oct 12, 2012 at 11:38 AM

Dear Chief P. Michael Payne:

When I stand on the Piedras Blancas bluffs, as a volunteer wildlife docent and I chat with visiting tourists from around the world about the remarkable marine life that fills the Central Coast waters, they gasp and find it hard to believe that such a special place still exists on this planet.

Now I fear eminent decimation of our marine life due to the unprecedented proposal of underwater seismic testing in the area near Diablo Canyon Nuclear facility.

"Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California, November to December, 2012," is an interesting National Marine Fisheries Service (NMFS) document that reviews the survey specifics as related to local marine mammals and marine life.

The 116-page report bounces like a seismic blast from "To avoid the potential for injury, NMFS (1995, 2000) concluded that cetaceans and pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding 180 and 190 dB re 1 µPa (rms), respectively," to (paraphrased in my own non-scientific language) promising that every precaution and stopgap protection of any and all marine life will take place at all times, to the very title of the document "Takes of Marine Mammals." a listing of possible "takes" of marine life.

An online news report writes, "Use of high-energy air guns is opposed by biologists, environmental groups, and fishermen, because the blasts could harm endangered whales, California sea otters, and other creatures that frequent the waters near the nuclear plant. John Calambokidis, an Olympia, Wash.-based marine biologist who has studied Pacific Ocean whales for decades, stated: "I am very concerned about impacts to marine mammals, especially some of the large whales including blue, fin, and humpback whales. There are many uncertainties on the impact of this type of operation on whales, especially since we have not seen this type of large air gun survey off California for a long time."

I urge a declining vote to approve PG&E's application to begin seismic surveys in 2012.

Sincerely,

Charmaine Coimbra

451 Worcester Dr., Cambria, CA 93428

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: PG&E Diablo Canyon Seismic Testing project

Howard Goldstein <howard.goldstein@noaa.gov> Tue, Oct 16, 2012 at 9:05 AM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Christina Osborn** <christinalee1223@gmail.com>
Date: Mon, Oct 15, 2012 at 10:00 PM
Subject: PG&E Diablo Canyon Seismic Testing project
To: Howard.Goldstein@noaa.gov

Dear Mr. Goldstein,

Because the staging parts of this project having been allowed to go ahead without the peoples input or a complete regulatory process, the baselines are shifted, and no study results will be trustworthy or accurate.Also, the whales are endangered already, and don't need to be harassed or worse. And because PG&E has stated they will make no plant upgrades regardless of the seismic results, seismic testing does nothing to improve our safety. Finally, this area being the core home of the species, Morro Bay Harbor Porpoises and Southern Sea Otters could be rendered completely extinct if this unnecessary seismic testing is allowed to go forward.

Signed,
--Christina Osborn-Lee

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

ITP Goldstein <itp.goldstein@noaa.gov>

PG&E seismic testing Central Coast

Christine Heinrichs <christine.heinrichs@gmail.com> Wed, Oct 10, 2012 at 9:35 PM
To: ITP.Goldstein@noaa.gov

9 October 2012

P. Michael Payne

Chief, Permits and Conservation Division

Office of Protected Resources

National Marine Fisheries Service

1315 East-West Highway

Silver Spring, MD 20910

ITP.Goldstein@noaa.gov

To the National Marine Fisheries Service:

I ask that you deny the Incidental Harassment Authorization for which Pacific Gas & Electric has applied in connection with its seismic testing project.

The National Science Foundation's draft Environmental Assessment differs substantially in its estimates of marine mammal take from the Final Environmental Impact Report adopted by the State Lands Commission in granting the permit for this project. The EA states:

"It is unlikely that the proposed action would result in any cases of temporary or especially permanent hearing impairment, or any significant non-auditory physical or physiological effects. Some behavioral disturbance is expected, if animals are in the general area during seismic operations, but this would be localized, short-term, and involve limited numbers of animals."

The SLC FEIR specifically notes Significant impacts on Harbor porpoises, Fin whales, Humpback whales, Blue whales, Bottlenose dolphins and Southern sea otters. This discrepancy needs to be addressed before an IHA is considered.

The wide range of marine mammals being affected is unacceptable and far outside the concept of ‘incidental harassment’ as defined: small numbers that will have a negligible impact on the species or stocks. The impact on the food species for these large marine mammals should also not be overlooked. If their food is destroyed by the seismic blasts, which may well happen, the area will become useless to them and they will be forced to find other feeding areas.

The report identifies substantial ‘impacts’ to marine mammals and commercial fishing, as well as air pollution. The table on page 4.4-79 of the EIR specifies Level A Take of marine mammals, all of which are protected under the Marine Mammal Protection Act. Many are also protected under the Endangered Species Act. The fish, fish eggs and fish larvae that will be destroyed are the food these animals require. When that is gone, the mammals will leave.

Northern elephant seals are dismissed in a couple of paragraphs. "The northern elephant seal is present year-round off of central California; however, because they spend very little time at the surface and forage mostly offshore, at-sea sightings are rare." (p. 87) No further concern is expressed. In fact, elephant seals spend most of their time deep in the ocean, where the killing blasts will be directed. The time period, from November 15 through December 31, when PG&E has been approved to blast, adult males are returning to the Central Coast from Alaska for the breeding season.

The level of sound blasts from the air guns isn’t just loud, it’s deafening, 250 decibels. David Sneed, environment reporter for the San Luis Obispo Tribune, described it as "There is no everyday equivalent for that level of sound. Most decibel charts list the loudest sound as a military jet aircraft taking off at 140 decibels."

The suggestion is often made that the animals can simply be chased out of the area. Blair Jones of PG&E claims that "As they (the boats) come into an area, they'll start emitting low-pulse sounds to warn marine life in the area. Those sounds will slowly ramp up until we get to the level that's needed to perform the survey."

The notion that marine mammals can be harmlessly chased out of the immediate area is misleading. It’s a direct violation of the Marine Mammal Protection Act, for good reason, Level B harassment. An IHA cannot change that. This is these animals’ habitat. They live there because their food is there and they navigate to their breeding grounds via these areas. Where are they supposed to go? Someplace where there is no food, or be sent off their migration routes to find other ways to their homes?

Northern Elephant Seals will be actively migrating through the area during November and December. Juveniles will be making their way to the beaches for a needed rest. Blasted away from their rookeries, will they find other beaches? Or will they swim off and die? Adult males will be returning in late November and December. They swim deep and are seldom seen at the surface. That doesn’t mean they aren’t there. It means they are right in the air gun target zone. They need to get on the beach to prepare for the mating season. What happens when they can’t get to the beach, or their internal organs are liquefied? Will they cancel breeding season? Not knowing the answers to these questions makes issuing an IHA impossible.

PG&E spokesmen stated at the State Lands Commission hearing that operations would be shut down if any marine mammal was within 1.1 miles. With hundreds of thousands of marine mammals living off our coast, that boat will always be within that radius of whales, seals, sea lions and otters. They cannot possibly assure that the blasting will not be within that range, considering the deep-diving mammals that live and migrate through the area,

even in the daytime. At night, it's even less possible to see them and stop operations.

Pacific Gas & Electric has been given permission to blast the coast with 250-decibel air guns, 24/7, for 33 days and nights. The justification for this elaborate, expensive and destructive project is: "PG&E's Geosciences staff believes that data gathered from the additional studies that comprise the Project would improve characterizations of these fault zones and allow PG&E to refine estimates of the frequency and intensity of ground motion that is likely to occur in the area surrounding and including the Diablo Canyon Power Plant. This information may also improve assessments of the potential seismic hazard at the DCPP."

The original proposal was for a longer period of blasting but was not assured of providing data that would provide significant information. The reduced time period and area covered is even less likely to produce useful information.

The data PG&E hopes (but can't be certain) this project will produce will not make Diablo Canyon Nuclear Plant any safer. No modifications are contemplated, no changes will be made. The data will be used to create an improved, 3-D computer model. PG&E reps are enthusiastic over how they would be able to rotate and slice this CAT-scan-like image, so superior to the conventional 2-D X-ray images they find so limiting. I don't underestimate the value of computer modeling in predicting future catastrophe, but weighing the certain damage against the dubious advantages of this technology makes Incidental Take unacceptable and unjustified in connection with this project.

Thank you.

Christine Heinrichs

1800 Downing Ave.

Cambria, CA 93428

805-203-5018

Christine.heinrichs@gmail.com

City of Morro Bay

HARBOR DEPARTMENT
1275 Embarcadero
Morro Bay, CA 93442
Ph. 805-772-6254
Fax: 805-772-6258

October 2, 2012

National Marine Fisheries Service,
Office of Protected Resources
Michael Payne, Chief of Permits and Conservation Division
1315 East-West Highway
Silver Spring, MD 20910

RE: OPPOSITION TO PG&E'S PROPOSED SEISMIC IMAGING PROJECT ON THE CENTRAL CALIFORNIA COAST

Dear Mr. Payne,

On September 6, 2012 the Morro Bay Harbor Advisory Board voted unanimously to support the Morro Bay City Council's resolution #49-12 (attached) unanimously opposing PG&E's proposed seismic imaging project on the Central California Coast. The Harbor Advisory Board is a diverse group of seven members appointed from the public representing the public and our working waterfront to advise the Morro Bay City Council on a broad array of harbor and ocean-related topics and issues.

In addition, the Harbor Advisory Board went unanimously on record with the following comments on the proposed project:

• That other, less damaging technology is sought to accomplish the seismic imaging needs of PG&E.
• That due to the unknown effects on marine life the seismic imaging as proposed is ill advised and should not be conducted unless more studies are done to gauge the true effects on marine life.
• That should the project go forward in any form an adequate compensation/mitigation plan must be in place for fishermen and impacted individuals/businesses for damages caused by the testing. At the least, said plan must be acceptable to the Morro Bay and Port San Luis Commercial Fisherman's Organizations.

Thank you for taking the comments of the Morro Bay Harbor Advisory Board into consideration.

Jim Phillips, Chair
Marine Oriented Business

Jeff Eckles, Vice Chair
Waterfront Leaseholders

Brett Cunningham
Commercial Fishing

Gene Doughty
Los Osos/Baywood

Bill Luffee
Marine Oriented Business

Dana McClish
Recreational Boating

Lynn Meissen
Member At Large

10-10-12 PRI

RESOLUTION NO. 49-12

RESOLUTION OF THE CITY COUNCIL OF THE CITY OF MORRO BAY, CALIFORNIA OPPOSING THE CENTRAL COASTAL CALIFORNIA SEISMIC IMAGING PROJECT

THE CITY COUNCIL
City of Morro Bay, California

WHEREAS, the Central Coastal California Seismic Imaging Project proposes to perform seismic testing from November 1, 2012 through December 31, 2012 in and around the waters of Morro Bay; and,

WHEREAS, the City of Morro Bay sent a letter to the California State Lands Commission regarding the Draft Environmental Impact Report outlining numerous concerns; and,

WHEREAS, those concerns included the extension of recreational rockfish season to December 31st, the short-term, long-term and permanent effects on fish, fishing, and fish stocks; the short-term, long-term and permanent effects on marine mammals; a portion of the seismic project boundary being located within a highly rich Marine Protected Area; and, the inability for vessels to leave and enter the Morro Bay Harbor; and,

WHEREAS, the project has not taken into consideration the land side impacts related to fishing that include, but are not limited to, reduced fish landing and processing activity, fish availability for restaurants, tourism and other environmental issues; and,

WHEREAS, the project has not identified an adequate mitigation and claims process for those affected; and,

WHEREAS, the project does not include an adequate monitoring plan for assessing fish stock recovery in either the short or long term periods.

NOW, THEREFORE, BE IT RESOLVED, that the City of Morro Bay opposes the Central Coastal California Seismic Imaging Project being proposed by Pacific Gas and Electric.

PASSED AND ADOPTED by the City Council of the City of Morro Bay at a regular meeting thereof held on the 11th of September 2012, by the following vote:

AYES: Borchard, Johnson, Leage, Smukler, Yates

NOES: None

ABSENT: None

WILLIAM YATES, Mayor

ATTEST:

JAMIE BOUCHER, City Clerk

ITP Goldstein <itp.goldstein@noaa.gov>

Diablo Canyon Nuclear Power Plant

cortez <cecate@pacbell.net> Sun, Sep 30, 2012 at 3:52 PM
To: itp.goldstein@noaa.gov

P.Michael Paine,
Chief of Permits and Conservation Division,
Office of Protected Resources,
National Marine Fisheries Service,
1315 East-West Highway, Silver Spring, MD

Dear Madam(s), Sir(s), and Mr. P. Michael Paine,

I strongly object to all disruption of sea-life including what is currently being endured. Particularly I object to any further disruption to the sea-life in and around Diablo Canyon that will occur if the planned testing is allowed.

I was a nuclear power plant worker and I realize that the need for power produced by Diablo Canyon is of high importance and concern. While this need is the core of this problem nothing can justify disruption of sea life that is part of the WORLD community.

For the fundamental reason that this is a world-wide issue I implore you to keep this thought in mind and beg you to realize the boundaries that are involved here; not the legal remedies that have been usurped; please render to the inhabitants that were here first and to whom the WORLD owes so much...Please require indisputable proof that the sea-life is protected ABSOLUTELY; if it takes another year, or TEN, or more, so be it.

Mr. Paine, I could write on this for days; as I am sure you could also. I know you can see the gravity of my simple argument and I certainly hope and expect you are a person (and of course your committee(s)) that has experienced the majesty of the inhabitants of our oceans.

All the best to you sir, and to your fellows, be strong.
cortez cate

556 Bakeman Lane
Arroyo Grande, CA 93420
(805) 481-7551

ITP Goldstein <itp.goldstein@noaa.gov>

PG&E purposal for seismic testing

Crystal Baker <lisimew@gmail.com> Mon, Oct 15, 2012 at 1:57 PM
To: itp.goldstein@noaa.gov

Dear Mr. Paine,

I am a member of the Coastal Band of the Chumash Nation. We are a tribe that have over 2000 members that are direct decendents that have occupied the Coastal of California from Ragged Point down to the Santa Monica Mountains and its Channel Islands for over 18,000 years. Attached will find a letter that I am submitting with a list of concerns with PG&E's purposal for 3D geophysical seismic testing. Thank you for your time. In Peace and Spirit -Crystal Baker

letter to Noaa.rtf
4K

Crystal Baker
Member of the
Coastal Band
of the Chumash Nation
P.O. Box 723
Atascadero, CA. 93423
email: lisimew@gmail.com
phone: (805)466-8406

P.Michael Paine,
Chief of Permits and Conservation Division,
Office of Protected Resources,
National Marine Fisheries Service,
1315 East-West Highway, Silver Spring, MD

re: 3D Geophysical Survey Using Airguns, hydrophones, & geophones

Dear Mr. Paine,

I am writing to you because we have gone over the high energy seismic survey process that is being proposed on California's Central Coast. We have several concerns with this process and the negetive impact it will have upon our marine relatives, our submerged cultural resources, and cultural and traditional take for medicinal uses with the waters of our traditional territories.

After reading reports of data that had been collected by other angencies after the 3D Geophysical Survey was done in other areas the conclusion was that the devestation to the Marine Ecosystem was ten times worse that that of commercial fishing that was done previousely with out enforcement of Marine Protected Areas. With that said we ask you not to permit seismic testing off of the Coast of California. Cultural Resource Village sites, sacred sites, and burial grounds that have submerged or has fallen into the ocean due to erosion are irreplaceable and the Eccosystem of the California Coast are not back to their fullest abundance. The 3D Geophysical Survey Using Airguns, hydrophones, & geophones will set back the marine environment to what it was when the Marine Life Protection Act Initiative had began.

The Coastal Band of the Chumash Nation has requested from the National Science Foundation and Pacific Gas and Electric to have meaningful consultation several times to resolve these concerns that we have. They have not yet done so. This goes against our rights to defend our Culture, our Ancestors, and our Marine relatives that is gauranteed under federal and state laws as well as the United Nations Declarations on the Right of Indigenous Peoples. Thank you for the opprotunity to have meaningful consultation between NOAA and the Tribes in the past and we will be looking forward

to meaningful consultations on this issue as well.

Sincerely,

Crystal Baker
member of
Coastal Band
of the
Chumash Nation

ITP Goldstein <itp.goldstein@noaa.gov>

NOAA Letter RE: PG&E Seismic Study

Juarez, Cynthia x5820 <JuarezC@co.monterey.ca.us> Wed, Oct 17, 2012 at 3:12 PM
To: 100-BoS Everyone <100-BoSEveryone@co.monterey.ca.us>, "Arago, Alec" <Alec.Arago@mail.house.gov>, "Dianne Feinstein (scheduling@feinstein.senate.gov)" <scheduling@feinstein.senate.gov>, "Barbara Boxer (scheduling@boxer.senate.gov)" <scheduling@boxer.senate.gov>, "Luis Alejo (assemblymember.alejo@assembly.ca.gov)" <assemblymember.alejo@assembly.ca.gov>, "William W. Monning" <assemblymember.monning@assembly.ca.gov>, "Sam Blakeslee (senator.blakeslee@senate.ca.gov)" <senator.blakeslee@senate.ca.gov>, "Anthony J. Cannella (senator.cannella@senate.ca.gov)" <senator.cannella@senate.ca.gov>, "Bauman, Lew x5113" <baumanl@co.monterey.ca.us>, "McKee, Charles J" <McKeeCJ@co.monterey.ca.us>, "Young, Benny x5862" <YoungB@co.monterey.ca.us>, "Chiulos, Nick x5145" <chiulosn@co.monterey.ca.us>, "Borkowski, Gail T. x5842" <BorkowskiGT@co.monterey.ca.us>, John Arriaga <jeaandassoc@aol.com>, Brent Heberlee <bheberlee@nossaman.com>, "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>
Cc: "D'Adamo, Annette x3045" <D'AdamoA@co.monterey.ca.us>, "Juarez, Cynthia x5820" <JuarezC@co.monterey.ca.us>, Robyn Boyer <RobynJEA@aol.com>, Erica Arriaga <Ericajea@aol.com>, 112-Clerk of the Board Everyone <112-ClerkoftheBoardEveryone@co.monterey.ca.us>, "Luis Alejo (sergio.sanchez@asm.ca.gov)" <sergio.sanchez@asm.ca.gov>, "Luis Alejo (linda.gonzalez@asm.ca.gov)" <linda.gonzalez@asm.ca.gov>, "Poschman, Hans" <Hans.Poschman@sen.ca.gov>

Good afternoon,

For your information the attached letter was signed on behalf of the Monterey County Board of Supervisors addressed to Office of Protected Resources National Marine Fisheries Services expressing concerns regarding PG&E proposal for offshore high-energy seismic study. See attached.

Thank you,

Cynthia Juarez

Monterey County Administrative Office
Intergovernmental & Legislative Affairs
168 W. Alisal Street, 3rd Floor
Salinas, CA 93901
W: 831-755-5820
F: 831-796-8644

101212 - NOAA LTR re PGE Seismic Study.pdf
388K

MONTEREY COUNTY

BOARD OF SUPERVISORS

FERNANDO ARMENTA, *Vice Chair, District 1*
LOUIS R. CALCAGNO, *District 2*
SIMÓN SALINAS, *District 3*
JANE PARKER, *District 4*
DAVE POTTER, *Chair, District 5*

October 12, 2012

P. Michael Payne, Chief, Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

Via email - ITP.Goldstein@noaa.gov

SUBJECT: Federal Register 9/19/12 - RIN 0648–XC072
NOAA - Takes of Marine Mammals Incidental to Specified Activities;
Marine Geophysical Survey off the Central Coast of California

Dear Mr. Payne:

On behalf of the Monterey County Board of Supervisors, I am writing to express our concerns regarding the Pacific Gas & Electric (PG&E) proposal for offshore high-energy seismic study near the Diablo Canyon Power Plant.

While we are concerned with the seismic safety of the region surrounding PG&E's Diablo Canyon Nuclear facility, those concerns must be balanced with the disturbance of marine mammals and fish in the environmentally sensitive survey areas.

PG&E plans to use the research vessel *Langseth* to tow an array of air guns through the waters that include two state marine protected areas which is adjacent to the Monterey Bay National Marine Sanctuary, the largest national marine sanctuary and one of the largest marine protected areas in the United States. The air guns emit loud sounds into the ocean that penetrate Earth's crust resulting in three-dimensional images of the earthquake faults near Diablo Canyon which are intended to give seismologists a better picture of the seismic danger facing the nuclear power plant. However, dozens of endangered species use these waters and the loud sounds emitted by the air guns could injure marine wildlife or drive it away from the area (McCauley, R.D. et al 2000).

One of the main concerns is that the high-energy sound blasts could disturb and/or damage animal life, particularly cetaceans such as whales, porpoises and dolphins, all of which use the area off of the Central Coast as a migratory route to and from their annual feeding and birthing areas. Marine mammals such as whales, porpoises and dolphins use sonar and hearing to navigate and communicate, such seismic testing could damage their sensitive systems leading them off-route and possibly missing critical milestones along their routes putting them at risk to be in the wrong areas at the wrong time of the year.

We request that PG&E seek alternatives to the manner in which it researches potential seismic safety concerns so that to the maximum degree practical these efforts protect and respect the marine protected areas and Monterey Bay National Marine Sanctuary, thereby preserving the environment and economic viability of our pristine coastal areas while simultaneously safeguarding the public.

Sincerely,

Dave Potter

Dave Potter, Chair
Monterey County Board of Supervisors

cc: Congressman Sam Farr
Senator Dianne Feinstein
Senator Barbara Boxer
Governor Gerald Brown
Assembly Member Luis Alejo
Assembly Member Bill Monning
Senator Anthony Cannella
Senator Sam Blakeslee
John Laird – Secretary, California Resources Agency
Monterey County Board of Supervisors
Lew C. Bauman – CAO, Monterey County
Charles J. McKee – County Counsel, Monterey County
Benny Young – Director, Resources Management Agency, Monterey County
Nicholas E. Chiulos – Director, Intergovernmental & Legislative Affairs, Monterey County
Clerk of the Board, Monterey County
John E. Arriaga – JEA & Associates
Brent R. Heberlee – Nossaman LLP

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Dana Vicars <dvicars64@gmail.com> Tue, Oct 16, 2012 at 1:26 AM
To: ITP.Goldstein@noaa.gov

to P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service.

Our concerns:

1. Proposal downplays the potential effect on marine life including fish, invertebrates and marine mammals.

2. Important studies that linked seismic surveys to strandings are not mentioned in proposal. Specifically the report by Gentry (2000) called "**Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000**" is not mentioned, let alone discussed in detail. Report by Malakoff 2002 called **"Suit ties whale deaths to research cruise"** only mentioned briefly without significant discussion. Other occurrences such as Madagascar stranding are not mentioned at all.

These are documented cases that have not been mentioned in proposal (read more detailed description in our previous **post**):

1. Mozambique 2006,

2. Gulf of California, 2002

3. Galapagos Islands, 2000

4. Madagascar, 2008

5. Peru, 2012

6. Interesting Statistics from Australia (2002-2004)

3. Crucial study that showed cardiorespiratory changes in beluga whale in response to acoustic noise is not even mentioned in proposal (**link**). In this study belugas were exposed to noise at much lower level than is planned in California and the animal demonstrated severe tachycardia "at lower noise intensities (as low as 140 dB);"

4. This proposal is rushed and the levels of impact are not investigated enough and not accessed based on the best scientific evidence available.

5. The company's planned actions lack transparency, they should be required to fully and publicly disclose where activities take place, what equipment will be used, exact Sound Pressure Levels, when activities will take place. Additionally, marine mammal observers logs where they record all marine mammal sightings should be publicly available.

6. The proposal lacks specifics of how strandings will be investigated. It does not include what protocol of stranding investigation will be, what independent organizations will investigate strandings, who and in what manner will look for the evidence of acoustic trauma, decompression sickness related embolism, hemorrhage, etc.

7. NMFS should deny the permit based on omission of the best scientific evidence available and inadequate

assessment of impact on marine life.

This message has been automatically translated: Portuguese -> English.

ITP Goldstein
<itp.goldstein@noaa.gov>

Enc: eye drops for OUR EYES .... (see it again)

Danielle Melo <dforeverbr@yahoo.com.br> **Mon, Oct 15, 2012 at 6:53 PM**
Reply-To: Danielle Melo <dforeverbr@yahoo.com.br>
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>

Do not kill the Marine Mammals!

SIMPLY FABULOUS!! NOT NEED WORDS!!

NOTICE
This message is intended only for the person (s) (s) indicated (s) and recipient (s), may contain confidential information protected by law. The incorrect transmission of message does not mean the loss of its confidentiality. If this message has been received by mistake, please send it back to the sender and delete immediately of your system. It is forbidden to any person other than the recipient, use, disclose, distribute or copy any part of this message.

DISCLAIMER
This message is destined Exclusively to the Intended receiver.
It may contain confidential or legally protected information.
The incorrect transmission of this message does not mean loss of its confidentiality.
If this message is received by mistake, please send it back to the sender and delete it from your system immediately.
It is forbidden to any person who is not the Intended receiver to use, reveal, distribute, or copy any part of this message.

Daimyo_-_Salut_au_Printemps.pps
8635K View as HTML Download

ITP Goldstein <itp.goldstein@noaa.gov>

Stop testing in water and save the marine animals; please stop emmediately

keeperofthecrafts@comcast.net <keeperofthecrafts@comcast.net> Sun, Oct 14, 2012 at 7:48 PM
To: ITP.Goldstein@noaa.gov

Please stop this senseless action of testing; This will kill our habitat

for the sea animals and do much destruction to our natural resources as well. I demand that you stop this;

As Christians we are charged to be good stewards of the Eartha and its resources. PLEASE send an email to ITP.Goldstein@noaa.gov and remind them that it is their purpose, according to their own website, "to prevent lost economic potential associated with overfishing, declining species and degraded habitats." And remind them that they are "responsible for the stewardship of the nation's living marine resources and their habitat."

Deborah Fowler
Oregon, IL

ITP Goldstein <itp.goldstein@noaa.gov>

Diablo Canyon/PG&E Proposed Seismic Studies

deepali panjabi <dpanjabi@hotmail.com> Fri, Oct 12, 2012 at 4:19 PM
To: itp.goldstein@noaa.gov

Dear NOAA:

I am writing to express my deep opposition to the conducting of seismic studies off the Central Coast of California as proposed by PG&E in relation to the Diablo Canyon Nuclear Power Plant.

I am horrified by the potential impacts of these studies to marine life. The studies will repeatedly blast deafening acoustic guns that will kill untold numbers of fish and marine mammals including whales, dolphins, seals, sea lions, sea otters, sea turtles, and countless species of fish. It will also have devastating consequences on larvae, causing an unprecedented impact on our ocean life for generations to come. Our ocean wildlife will be harassed and injured. There will also be severe negative impacts on the fishing and tourism industry. All this to extend the life of a nuclear power plant that is long overdue to retire. This is absolutely unconscionable.

The Central Coast of California is a national treasure. Parts of the proposed survey areas are declared Marine Sanctuaries. Untold numbers of precious wildlife call this area home or migrate through these waters as demonstrated just this past summer. Please act as stewards of our precious coast and marine life by unconditionally rejecting PG&E's proposal to conduct these seismic studies.

Sincerely,

Deepali Panjabi

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Stop diablo canyon seismic testing!

Howard Goldstein <howard.goldstein@noaa.gov> Tue, Oct 16, 2012 at 9:05 AM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **deirdre steinmetz** <deirdre13@yahoo.com>
Date: Mon, Oct 15, 2012 at 11:20 PM
Subject: Stop diablo canyon seismic testing!
To: "howard.goldstein@noaa.gov" <howard.goldstein@noaa.gov>

Dear Mr. Goldstein,

I am writing to ask that you do what is possible to STOP Diablo Canyon seismic testing. The California Fish & Game Commission derided the project as ecologically risky and scientifically unnecessary and the Natural Resources Defense Council (NRDC) now say the project would create environmental devastation with no clear benefit. As PG&E has stated they will make no plant upgrades regardless of the seismic results, seismic testing does nothing to improve our safety.
The testing further endangers our whales and this area being the core home of the species, Harbor Porpoises and Otters could be rendered completely extinct if this unnecessary seismic testing is allowed to go forward.

Please help protect our marine mammals!

Sincerely,

Deirdre Steinmetz

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417

Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

ITP Goldstein <itp.goldstein@noaa.gov>

Michael Payne Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service

denise linn <deniselinn@mac.com> Mon, Oct 15, 2012 at 12:16 PM
To: ITP.Goldstein@noaa.gov

Dear Michael,

I'm sure you know of all the reasons why the seismic testing isn't a good idea. I know your office has been inundated with pleas on behalf of the sea. However, one added aspect to consider as well is the HUGE international fervor that will occur when the dead animals start coming to shore. The international maelstrom will be on mythic proportions. Please consider doing what you can to stop this from occurring.

Denise Linn

9/19/12

Dear Mr. Payne —

Please do not approve Diablo Canyon's proposed seismic testing plans. These tests are totally unnecessary & will only devastate our marine life & our local economy. Who wants to visit our gorgeous Central CA coast to witness death on our beaches? Please help us keep our Pt. Buchon Marine area safe & pristine.

Thank you for your consideration.

Respectfully —

Diane Smith
402 Montebello Oaks Dr.
Paso Robles CA
93446

RECEIVED
09-25-12
PRI

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Diablo Canyon Seismic Testing

Howard Goldstein <howard.goldstein@noaa.gov> Mon, Oct 15, 2012 at 5:11 PM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Diane Smith** <celebratepaso@gmail.com>
Date: Mon, Oct 15, 2012 at 5:10 PM
Subject: Diablo Canyon Seismic Testing
To: Howard.Goldstein@noaa.gov

Dear Mr. Goldstein ~

I would like to ask that you deny PG&E's seismic testing along the Central California coast (Diablo Canyon Nuclear Power Plant). This testing is totally unnecessary. The NRC has even retracted their approval & are now asking the CA Coastal Commission to deny the permit. The tests will definitely harm/kill the marine life in our local ocean reserves which, in turn, will devastate our local economy with dead sea life on our shores.

I hope your agency will stand up to protect our oceans/marine life and deny this permit. It is imperative that our oceans remain healthy for the present and future generations to enjoy.

PLEASE DENY SEISMIC TESTING. Thank you, in advance, for your consideration.

Respectfully,
Diane Smith
402 Montebello Oaks Drive
Paso Robles, CA 93446

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

NOAA FISHERIES

ITP Goldstein <itp.goldstein@noaa.gov>

Conscientious objections to further seismic study on the Central Coast of California

Dr. C. Hite <aaaptly@gmail.com> Tue, Oct 16, 2012 at 12:34 AM
To: ITP.Goldstein@noaa.gov

On Mon, Oct 15, 2012 at 2:34 PM, Dr. C. Hite <aaaptly@gmail.com> wrote:

Mr. P. Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries1315 East-West HWY
Silver Springs, MD 20910

RE: 15 Arguments against further seismic testing on the Central Coast of California

By Dr. C. Hite, Los Osos, California

World Community Workshop

(Arguments highlighted in yellow)

1) There have been NO scientific studies on the adverse affects on wildlife from the 2011 Seismic testing throughout Los Osos and the County of San Luis Obispo, California.

2) There has been no scientific release of data from this 2011 seismic ground testing.

3) It would be prudent for PG&E to compile the data from the ground seismic testing first to see if shoreline, estuary and offshore seismic study is necessarily.

4) PG&E should be required to release the scientific information on the low energy seismic research off portions of the California Central Coast before proceeding with the controversial high decibel seismic study.

5) Further seismic study should NOT be allowed to proceed without guidelines. NOAA has yet to develop marine mammal acoustic guidelines.

6. San Luis Obispo County has NO marine mammal stranding network to report to.

7) The nitrogen hot fertilizer of organic flotsam from the seismic study "take" will clog the cooling water intake of Diablo Canyon Nuclear Power Plant, making it unreliable.

8) PG&E will be acting against it's own stated commitment to the "environment" for the purpose of extending the license of the Diablo Canyon Nuclear Power Plant.

9) PG&E Diablo Canyon Nuclear Power Plant is aged, scheduled for decommission and is unreliable

10) The Central Coast rate payers had NO vote on paying for the seismic study and have NO vote to shut the plant down as did the Sacramento rate payers.

11) Continued seismic study is specific to "ensuring that Diablo Canyon continues" by not just extending the life span but providing an "after life" to Diablo Canyon Nuclear Power Plant

12) We have NO comparisons to see if similar testing by oil companies have used this "similar testing" *safely* because not all have taken the

same "multi-tiered monitoring program" approach.

13) There is insufficient scientific data to determine if the "ramping up" of sound to full power will drive marine mammals into the many coves off the Central Coast and aground.

14) PG&E expects that there will be marine mammal stranding.

15) Diablo Canyon Nuclear Power Plant is NOT required to protect the "Nation."

> **http://www.pge.com/myhome/edusafety/systemworks/dcpp/**
>
> **newsmedia/seismic/index.shtml**
>
> [Quoted text hidden]
> [Quoted text hidden]
> http://marinelife.about.com/od/conservation/a/sonarCA.htm
> [Quoted text hidden]

ITP Goldstein <itp.goldstein@noaa.gov>

Conscientious objections to further seismic study on the Central Coast of California

Dr. C. Hite <aaaptly@gmail.com>
To: ITP.Goldstein@noaa.gov
Cc: Amy.Scholik@noaa.gov

Mon, Oct 15, 2012 at 5:34 PM

Mr. P. Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries1315 East-West HWY
Silver Springs, MD 20910

RE: 15 Arguments against further seismic testing on the Central Coast of California

By Dr. C. Hite, Los Osos, California

World Community Workshop

(Arguments highlighted in yellow)

1) There have been NO scientific studies on the adverse affects on wildlife from the 2011 Seismic testing throughout Los Osos and the County of San Luis Obispo, California.

2) There has been no scientific release of

data from this 2011 seismic ground testing.

3) It would be prudent for PG&E to compile the data from the ground seismic testing first to see if shoreline, estuary and offshore seismic study is necessarily.

4) PG&E should be required to release the scientific information on the low energy seismic research off portions of the California Central Coast before proceeding with the controversial high decibel seismic study.

http://www.pge.com/myhome/edusafety/systemworks/dcpp/newsmedia/seismic/index.shtml

Seismic Studies Update

During the week of August 20, 2012, PG&E will resume low-energy seismic research work off portions of California's Central Coast.

PG&E began the first phase of this low-energy offshore study in 2010, and completed the second portion in 2011. The third phase will study areas near San Luis Bay, Estero Bay and Point Sal.

All operations will be performed during daylight hours and processes and procedures have been implemented to monitor and protect marine mammals while the study is underway.

Mariner and commercial boat traffic are encouraged to remain at least a mile away from the vessel while it operates in the area to avoid entanglement with research equipment. Daily updates on the location of the vessel can be found at www.marinetraffic.com using the search word "Pacific Star."

#

5) Further seismic study should NOT be allowed to proceed without guidelines. NOAA has yet to develop marine mammal acoustic guidelines.

http://www.nmfs.noaa.gov/

Ocean Acoustics

The NOAA Fisheries Acoustics Program is investigating all aspects of marine animal **acoustic communication**, **hearing**, and the **effects of sound** on behavior and hearing in **protected marine species**. Specifically, the program is:

- Developing acoustic exposure policy for NOAA
  - Developing marine mammal acoustic guidelines
  - Providing technical analysis for NOAA Incidental Take Authorizations and Biological Opinions involving human sound sources based on the best available marine mammal acoustic science
- Supporting research in a variety of areas to address critical data needed to improve and expand these criteria (working directly with NOAA Fisheries Office of Science and Technology)
  - Leading efforts to develop a global passive acoustic noise-monitoring network [pdf] in key marine environments around the world

More on Acoustics

- Guidelines
- Shipping Noise
- Sonar
- Behavioral Response Studies/ Controlled Exposure Experiments

Humpback whales
(Megaptera novaeangliae)
Photo: R. Wicklund, NOAA

More Information

- Cetacean and Sound Mapping Working Groups
- Federal Task Force on Anthropogenic Sound (JSOST 2009) [pdf]
- Shipping Noise
- Sonar
- Behavioral Response Studies/Controlled Exposure Experiments
- NOAA Fisheries
  - Alaska Fisheries Science Center
  - Northeast Fisheries Science Center
  - Northwest Fisheries Science Center
  - Pacific Islands Fisheries Science Center
  - Southeast Fisheries Science Center
  - Southwest Fisheries Science Center
- NOAA VENTS Program
- Stellwagen Bank National Marine Sanctuary
- Learn more about sound

Updated: October 11, 2012

#

6. San Luis Obispo County has NO marine mammal stranding network to report to.

Southwest Region Marine Mammal Stranding Network

California

- NMFS Southwest Regional Office
  Long Beach, CA
  562-980-3230

- NMFS Southwest Fisheries Science Center
  La Jolla, CA
  858-546-7162
  Dead Cetaceans and Pinnipeds; Sea Turtles

- California Academy of Sciences
  Department of Ornithology and Mammalogy
  San Francisco, CA
  415-379-5381
  Dead Cetaceans and Pinnipeds; Sea Turtles

- California Wildlife Center
  Malibu, CA
  310-458-9453 or 818-222-2658
  Live Cetaceans and Pinnipeds; Sea Turtles

- Channel Islands Marine & Wildlife Institute
  Goleta, CA
  805-567-1505
  Live Cetaceans and Pinnipeds; Sea Turtles

- Humboldt State University - Vertebrate Museum
  Arcata, CA
  707-826-4872
  Dead Cetaceans; Sea Turtles

- Long Marine Lab, University of California
  Santa Cruz, CA
  831-212-1272
  Live Cetaceans
  Dead Cetaceans and Pinnipeds; Sea Turtles

- Los Angeles County Museum of Natural History
  Los Angeles, CA
  323-585-5105
  Dead Cetaceans; Sea Turtles

- Marine Animal Rescue
  El Segundo, CA
  800-39-WHALE
  Live Cetaceans and Pinnipeds; Sea Turtles

- Marine Mammal Care Center at Fort MacArthur
  San Pedro, CA
  310-548-5677
  Live Cetaceans and Pinnipeds; Sea Turtles

- Moss Landing Marine Laboratories

Moss Landing, CA
831-771-4422
Dead Cetaceans and Pinnipeds; Sea Turtles

- Northcoast Marine Mammal Center
  Crescent City, CA
  707-465-6265
  Live Cetaceans and Pinnipeds; Sea Turtles

- Pacific Marine Mammal Center
  Laguna Beach, CA
  949-494-3050
  Live Cetaceans and Pinnipeds; Sea Turtles

- Santa Barbara Marine Mammal Center
  Santa Barbara, CA
  805-687-3255
  Live Cetaceans and Pinnipeds; Sea Turtles

- Santa Barbara Museum of Natural History
  Vertebrate Laboratory
  Santa Barbara, CA
  805-682-4711 x156
  Dead Cetaceans; Sea Turtles

- SeaWorld
  San Diego, CA 92109
  800-541-7325
  Live Cetaceans and Pinnipeds; Sea Turtles

- The Marine Mammal Center
  Sausalito, CA
  415-289-7350
  Live Cetaceans and Pinnipeds; Sea Turtles

#

7) The nitrogen hot fertilizer of organic flotsam from the seismic study "take" will clog the cooling water intake of Diablo Canyon Nuclear Power Plant, making it unreliable.

http://www.pgecurrents.com/2012/04/27/san-luis-obispo-county-diablo-canyon-powers-down-after-sea-salp-migration/

Posted on April 27, 2012

San Luis Obispo County: Diablo Canyon Powers Down after Sea Salp Migration

Diablo Canyon Power Plant in San Luis Obispo County

AVILA BEACH – PG&E has powered down Unit 2 at its Diablo Canyon Power Plant after a migration of small jellyfish-like creatures known as sea salps.

As reported by the *San Luis Obispo Tribune*, southerly winds began blowing the salps into the plant's cooling water intake cove on Tuesday. Plant operators noticed differences in water pressure at the intake structure, which meant the salps were beginning to clog the rolling screens in front of the intake.

After initially reducing power in Unit 2 to 15 percent, the problem with the animals first got better and then got worse. So, on Wednesday, the decision was made to fully power down the plant.

"I've been very pleased with how staff has reacted to this by putting safety first," Ed Halpin, PG&E's chief nuclear officer, told the newspaper.

Small jellyfish-like creatures called sea salps are in the water near Diablo Canyon.

Millions if not billions of sea salps, a one- to three-inch long transparent barrel-shaped animal that looks and feels much like a jellyfish, came ashore in the area with onshore currents. These creatures feed on plankton, and multiply rapidly.

The plant will return to full power as soon as it is safe to do so, and conditions warrant, Halpin said.

John Lindsey, a PG&E spokesman and meteorologist based in San Luis Obispo, said Friday that the winds have now changed direction in the area, and the salps should begin heading out to sea.

The Diablo Canyon intake provides seawater for cooling. It is 240-feet long, 100-feet wide and 18-feet high. It

extends down 32 feet below sea level. The intake structure is backfilled by rock on three sides, and has water on the fourth (western) side.

The intake relies on four, 13,000-horsepower electric motors to pump 1.7 million gallons per minute or up to 2.5 billion gallons per day. In other words, the circulating water system provides the heat sink required for removal of waste heat in the power plant's thermal cycle. The circulating water system is designed to provide cooling water necessary to condense the steam entering the main condenser.

A curtain wall at the front of the intake structure limits the amount of floating debris entering the intake structure. Bar racks near the front of the intake structure intercept large submerged debris. Traveling screens intercept all material larger than the screen mesh opening, which measure 3/8ths of an inch.

The intake also houses the Auxiliary Salt Water (ASW) pumps. The ocean water supply to the ASW system provides the cooling and heat absorption capability required to remove waste heat under normal and emergency conditions.

The two units of Diablo Canyon produce approximately 2,300 net megawatts of greenhouse-gas-free electricity, about 10 percent of all electricity generated in California. That's enough to meet the needs of over three million homes in central and northern California. Unit 1 at the nuclear power plant was shut down for refueling starting on April 23.

#

8) PG&E will be acting against it's own stated commitment to the "environment" for the purpose of extending the license of the Diablo Canyon Nuclear Power Plant.

https://mail.google.com/mail/?shva=1#drafts/13a65f7cf279a230

PG&E's Environmental Commitment

At PG&E, we are committed to being an environmental leader and demonstrating this through our actions. We pledge to think creatively, work cooperatively and be results-oriented in our environmental stewardship efforts.

#

9) PG&E Diablo Canyon Nuclear Power Plant is aged, scheduled for decommission and is unreliable

http://www.pge.com/myhome/edusafety/systemworks/dcpp/newsmedia/pressrelease/archive/unit_2_at_pges_diablo_canyon_power_plant_safely_shut_down_following_electrical_disturbance.shtml

Unit 2 at PG&E'S Diablo Canyon Power Plant Safely Shut Down Following Electrical Disturbance

October 11, 2012

AVILA BEACH, Calif. – Unit 2 at Pacific Gas and Electric Company's (PG&E) Diablo Canyon Power Plant safely shut down as designed at 12:08 p.m. today after an electrical disturbance occurred in equipment that moves power to the state's electric grid. Unit 1 continues to safely generate power.

Plant operators responded to the shutdown according to procedures and are working to determine the cause of the incident. The unit remains in a safe condition and will be restored to service after the cause is fully understood and the equipment is fully tested.
PG&E has informed the U.S. Nuclear Regulatory Commission and appropriate local and state officials.

Pacific Gas and Electric Company, a subsidiary of PG&E Corporation (NYSE:PCG), is one of the largest combined natural gas and electric utilities in the United States. Based in San Francisco, with 20,000 employees, the company delivers some of the nation's cleanest energy to 15 million people in Northern and Central California. For more information, visit http://www.pge.com/about/newsroom/ and www.pgecurrents.com.

#

http://marinelife.about.com/od/conservation/a/sonarCA.htm

#

10) The Central Coast rate payers had NO vote on paying for the seismic study and have NO vote to shut the plant down as did the Sacramento rate payers.

http://www.energy-net.org/01NUKE/RSECOT.HTM

The History of Rancho Seco

1966-1969

SMUD purchases 2,100 acres in southeast Sacramento County for a nuclear power plant. Construction begins on the cooling towers.

1971

- SMUD raises rates...even though Rancho Seco hasn't produced a single kilowatt-hour of electricity.
- The day Rancho Seco is dedicated there is a forced shutdown of the reactor (unknown to those attending the dedication ceremony)... a portent of things to come. [10/19/74]
- The turbine breaks down. The plant is shut down for 13 of the first 18 months of operation.

1976

- Loose parts are found in Rancho Seco's generator. SMUD says the find "will not cause any additional lost time." The plant is down for six months. [4/9/76, SB]

1978

- Rancho Seco shuts down four times. Problems are due to a dangerously fast cooldown.

1979

- Radioactive iodine is found in milk from cows grazing near Rancho Seco. [Quarterly Radiation Report on Rancho Seco]

1980

- Rancho Seco shuts down six times. Problems occurred with pipe supports, reactor coolant leaks, malfunctions, turbine bearings and feedwater flow. [9/26/83, SU]
- SMUD is fined $25,000 by the NRC for violating federal safety standards.

1981

- A state report on emergency planning estimates that a serious nuclear accident at Rancho Seco could result in as many as 76,000 deaths and 110,000 injuries. [11/2/80, SB]
- Rancho Seco shuts down 12 times. Problems are due to steam generator tube leaks, feedwater, reactor coolant pump and turbine vibrations. [9/26/83, SU]

1982

- Rancho Seco shuts down 11 times, due to problems with the turbine, steam leaks, oil pressure and reactor trips. [9/26/83, SU]
- SMUD is fined $120,000 for violating federal safety regulations.
- The steam generator leaks again...more radioactive steam escapes. Another shut-down.

1983

- Rancho Seco shuts down five times, due to maintenance, re-fueling, modifications, oil pressure in turbine generator, heat imbalance in reactor and leak in steam generator tube. [9/26/83, SU]
- The steam generator tubes leak again and more radioactive steam escapes into the atmosphere. The plant is shut down again.
- SMUD faces a lack of skilled workers for Rancho Seco. [3/6/83, SB]

1984

- Rancho Seco is on the NRC's list of the ten worst nuclear plants in the U.S. in overall assessment of management performance. [3/28/89, Public Citizens Mishaps Report, NRC]
- More than two billion gallons of water containing radiation levels above federal guidelines have been dumped from Rancho Seco into a creek that feeds the Cosumnes and Mokelumne Rivers, SMUD officials confirmed. [4/14/84, SB]
- Two workers are killed by high-pressure steam bursting from a boiler at Rancho Seco.
- An explosion and fire shut down Rancho Seco for 38 days.

1985

- SMUD raises rates twice...by nearly 30 percent. SMUD has the first budget deficit in its history. From January 1, 1985 to March 31, 1988, Rancho Seco operates only three months (out of three and one-quarter years).
- On December 26, Rancho Seco suffers thethird-fastest shut-down in U.S. reactor history when a control circuit malfunctions. The sudden temperature change could have cracked the reactor vessel and led to a meltdown.

- SMUD customers are now paying 40 percent more than a year ago. Rancho Seco work is $27 million over budget and another rate increase is being considered.

1986

- Sacramentans for SAFE Energy (SAFE) calls for the SMUD board of directors to commission an independent, comprehensive study of the safety and economic risks associated with Rancho Seco as well as a comparison of alternative means of meeting our energy needs.
- Rancho Seco assistant manager for nuclear operations Dan Whitney said plant managers sometimes deliberately withheld information about system shortcomings when questioned by the NRC. [5/22/86, SB]
- SMUD admits that Rancho Seco was "mismanaged, mismaintained and misoperated" its entire lifetime. [5/20/86, SB]
- Two Rancho Seco workers are fired for drug abuse. They claim there is drug abuse throughout the plant.

1987

- wo water leaks lead to the release of approximately 10,000 gallons of radioactive water, some of it flowing into the nearby creek, outside of the plant's boundaries...[3/28/89, Public Citation of Mishaps, NRC]
- In 1987, SMUD pays more than $350,000 in cash bonuses to fill positions at Rancho Seco. [7/10/88, SB]
- "Rates have increased 84 percent since March 1985, leading to ratepayer dismay and a situation in which half of SMUD households pay more than if served by surrounding Pacific Gas and Electric Company. " [10/23/87, SB]
- Chief of nuclear operations, John Ward, is fired despite reputation as a fixer of hopeless cases."It was like being in charge of the Keystone Kops," says Ward. [9/23/86]

1988

- "Closing Rancho Seco is the option for the future of SMUD that makes the most sense." [3/2/88, Sacramento Bee Editorial Staff]
- "The never-ending series of mishaps are beginning to look like a very high-budget Marx Brothers film, with Harpo in charge of warning the city should there be an emergency." [2/19/88, TV 40 Editorial Comment]
- A SMUD-commissioned, $824,000 QUEST study team recommends closure of Rancho Seco, saying that unstable operation of Rancho Seco could bankrupt SMUD.
- Rancho Seco operates at less than 37%--even less than its lifetime capacity average of 39%. Rates have increased almost 92% since March 1985 due to Rancho Seco problems. [INPO]
- The October 1988 SMUD bond prospectus states, "The District has concluded that terminating Rancho Seco in June 1989 would not have a materially adverse impact on the District's operations through December, 1999." [SMUD]
- Measure B (to close Rancho Seco) loses on the June ballot by the narrowest of margins--only two votes per precinct. Measure C (to give Rancho Seco a trial run) barely passes.
- Rancho Seco supporters promise stability and low electric rates for SMUD. However, immediately following the June 1988 election, SMUD General Manager Richard Byrne is fired, Rancho Seco chief of nuclear operations resigns and SMUD discloses the need for additional rate increases. Two SMUD chiefs get $520,000 in severance pay and bonuses.
- Former SMUD general manager Richard Byrne said he was "stifled, pressured and threatened by pro-Rancho Seco board members who wanted to keep potentially damaging information from reaching the public before the June 7, 1988 election. [6/18/88, SB]
- SMUD gives out $248,500 in bonuses to middle- and upper-level employees in May for "extraordinary service." About 80 percent ($197,000 was awarded to Rancho Seco managers and the balance to employees at SMUD headquarters. [9/1/88,SB]
- SMUD secretly paid out more than 970,000 in cash and benefits to eight managers who were forced to leave the utility during the past two years. [11/17/88, SB]
- Operating Rancho Seco in 1988 cost nearly twice the amount it would have cost SMUD to have purchased the same amount of electricity from other utilities. [12/26/88, SU]
- December 12--Operators try to restart Rancho Seco with malfunctioning valves. They rig the system in a

manner for which there are no written procedures. One of two steam generators runs dry. NRC officials say operators took the plant through "uncharted waters" and showed poor judgment in handling the restart.

1989

- On January 31 Rancho Seco shuts down. Two days later, radioactive gas is released into the environment. The plant is down for 45 days. Bill Chapin, Rancho Seco plant mechanical maintenance supervisor and co-chairman of the Rancho Seco Political Action Committee says, "I think there's no doubt, the Ranch cannot have another breakdown between now and June, politically speaking." A day after his quote, Rancho Seco goes down yet another time. [3/28/89, SB]
- SMUD and PG&E contract ensures cheap, reliable power for Sacramento through l999. [2/27/89, SU]
- The nuclear industry's own Institute of Nuclear Power Operations prepares a report on the recent shutdowns at Rancho Seco, saying that Rancho Seco's prior operating history as well as recent shutdowns "cause us to have a renewed concern over the quality of Rancho Seco operations." [INPO]
- SMUD pays $1,230 for one Rancho Seco employee's clothing as part of the "distinctive attire" program. Jackets, pants, shirts and ties have already cost $72,000; laundry bills, $2,500 a month--all ultimately paid by the ratepayers.
- The plant comes to an abrupt halt (is scrammed) on the 10th anniversary of the Three Mile Island meltdown. High-level radioactive gasses are vented to the atmosphere. On April 8 the reactor is started, even though the cause of the March 28 accident has not been found and malfunctioning equipment (from the March 15 accident) has not been repaired. [3/29/89, SB, SU]
- June 6th, 1989 Sacramento Citizens go to the polls and vote to permanently close Rancho Seco.

Sources: SB: Sacramento Bee, SU Sacramento Union xxx The above was a poster created for Measure K on June 6, 1989

#

11) Continued seismic study is specific to "ensuring that Diablo Canyon continues" by not just extending the life span but providing an "after life" to Diablo Canyon Nuclear Power Plant

http://www.pge.com/myhome/edusafety/systemworks/dcpp/newsmedia/seismic/index.shtml

Seismic Information

Seismic Safety

PG&E remains focused on ensuring that Diablo Canyon continues, and improves upon, its strong record of safe operations. This includes making the facility resilient to natural hazards, including earthquakes and tsunamis.

PG&E is the only utility in the country that employs a seismic department staffed with experts. The scientific staff continually studies earthquake faults in the region of the power plant and global seismic events as part of the plant's comprehensive safety program.

In November 2008, the U.S. Geological Survey (USGS), working in partnership with PG&E's geosciences department, discovered a new shoreline fault zone, and PG&E evaluated whether that new feature presented a safety risk to the plant. PG&E submitted its evaluation to the Nuclear Regulatory Commission (NRC) under the commitment of its current operating licenses. PG&E's evaluation confirmed the plant has adequate safety margin to withstand maximum ground motions postulated to occur from faults in the region, including the shoreline fault.

Advanced Seismic Research

PG&E is currently conducting advanced seismic studies that will provide a more accurate and detailed picture of the region’s complex geology. The research, called for by the state, will help further define the amount of ground

motions that seismic faults in the region are capable of producing.

PG&E has made steady progress toward completing the studies since the research began in 2010. The on-shore work is nearly complete, the majority of the low-energy off-shore studies are finished, and the California Coastal Commission has approved PG&E's request to install ocean-bottom seismometers to detect seismic activity.

The company plans to undertake the final, off-shore high-energy study as soon as it obtains all necessary permits from various regulatory agencies, including the State Lands Commission, California Coastal Commission and County of San Luis Obispo. To address public concern regarding the seismicity of the area surrounding Diablo Canyon, PG&E has worked to expedite the permitting process so it can begin this study as soon as possible. PG&E is committed to conducting this work safely and in a manner with the least impact to the community and the environment.

Once the research is complete, PG&E will use the data to support its ongoing work to continually assess and validate the seismic design of the plant. PG&E will also share information collected with local public and government agencies so they can incorporate it into emergency preparedness plans and ensure the safety of critical infrastructure. The data will also be used to support federal requirements for new seismic risk evaluations following the Fukushima Daiichi power plant tragedy in Japan.

Seismic Studies Update

During the week of August 20, 2012, PG&E will resume low-energy seismic research work off portions of California's Central Coast.

PG&E began the first phase of this low-energy offshore study in 2010, and completed the second portion in 2011. The third phase will study areas near San Luis Bay, Estero Bay and Point Sal.

All operations will be performed during daylight hours and processes and procedures have been implemented to monitor and protect marine mammals while the study is underway.

Mariner and commercial boat traffic are encouraged to remain at least a mile away from the vessel while it operates in the area to avoid entanglement with research equipment. Daily updates on the location of the vessel can be found at www.marinetraffic.com using the search word "Pacific Star."

Seismic Information

- August 2012 Status Report to ASLB on Seismic Studies (PDF, 83 KB)
- July 2012 Status Report to ASLB on Seismic Studies (PDF, 83 KB)
- June 2012 Status Report to ASLB on Seismic Studies (PDF, 83 KB)
- May 9, 2012 Status Report to ASLB on Seismic Studies (PDF, 83 KB)
- May 8, 2012 Status Report to ASLB on Seismic Studies (PDF, 83 KB)
- April 2012 Status Report to ASLB on Seismic Studies (PDF, 83 KB)
- March 2012 Status Report to ASLB on Seismic Studies (PDF, 81 KB)
- February 2012 Status Report to ASLB on Seismic Studies (PDF, 83 KB)
- January 2012 Status Report to ASLB on Seismic Studies (PDF, 82 KB)
- December 2011 Status Report to ASLB on Seismic Studies (PDF, 81 KB)
- November 2011 Status Report to ASLB on Seismic Studies (PDF, 83 KB)
- October 2011 Status Report to ASLB on Seismic Studies (PDF, 92 KB)
- September 2011 Status Report to ASLB on Seismic Studies (PDF, 91 KB)
- August 2011 Status Report to ASLB on Seismic Studies (PDF, 91 KB)
- July 2011 Status Report to ASLB on Seismic Studies (PDF, 98 KB)
- PG&E High Energy 3-D Seismic Scoping Presentation Before the State Lands Commission
- California Coastal Commission's Report on DCPP Safety From Tsunamis and Earthquakes (PDF, 661 KB)
- NRC releases post-Fukushima 90 day report (PDF, 899 KB)

Seismic Survey Topics

NRC Related Correspondence
Ocean Bottom Seismometer Study
2D/3D Low Energy Marine Studies
3D High Energy Marine Studies
Fishing Reading Room

Diablo Canyon Newsroom

- Unit 2 at PG&E'S Diablo Canyon Power Plant Safely Shut Down Following Electrical Disturbance
- PG&E to Submit Modified Seismic Study Proposal to California Coastal Commission
- PG&E Names New Diablo Canyon Site Vice President
- PG&E Supports Cal Poly Athletics with $20,000 Donation
- View all News Releases

Articles and Perspectives About Diablo Canyon

San Luis Obispo County: PG&E Taking Extensive Measures to Protect Marine Life in Seismic Testing

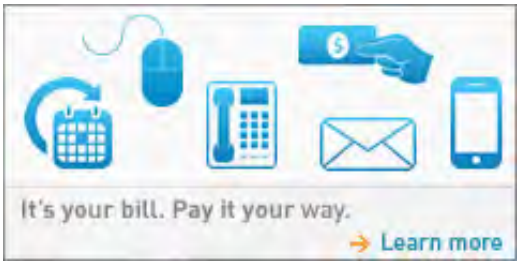
Trails Near Diablo Canyon Plant Offer Stunning Views of Coastal Scenery

San Luis Obispo County: State Lands Commission Approves Seismic Testing

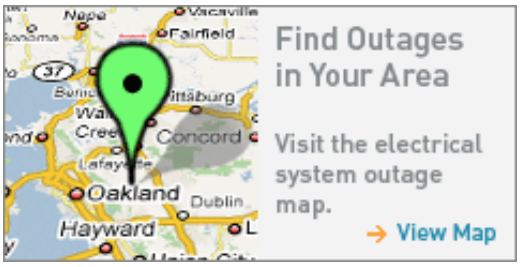
San Luis Obispo County: Delano Students Get an Insider's View of Diablo Canyon Power Plant

San Luis Obispo County: Diablo Canyon Powers Down after Sea Salp Migration

View all articles

- 

-

- 

#

12) We have NO comparisons to see if similar testing by oil companies have used this "similar testing" *safely* because not all have taken the same "multi-tiered monitoring program" approach.

http://www.pgecurrents.com/2012/09/07/san-luis-obispo-county-pge-taking-extensive-measures-to-protect-marine-life-in-seismic-testing/

With PG&E seeking approvals to conduct the final high-energy study, concerns have been raised about the affect the survey's high-decibel sounds will have on marine life. PG&E is mindful of these concerns, Strickland said, and is making every effort to mitigate potential impacts.

Other companies – including those in the oil industry — have used similar testing safely, he said. However, he said not all have taken the same "multi-tiered monitoring program" approach that PG&E has planned to protect marine life.

#

13) There is insufficient scientific data to determine if the "ramping up" of sound to full power will drive marine mammals into the many coves off the Central Coast and aground.

http://www.pgecurrents.com/2012/09/07/san-luis-obispo-county-pge-taking-extensive-measures-to-protect-marine-life-in-seismic-testing/

We are going above and beyond what other companies have implemented to date," he said.

PG&E continues to take many steps to ensure and improve the safety of its Diablo Canyon Power Plant.

For example, before a survey track begins, a single air gun will sound at a low-level to warn marine life before ramping up to full power. The air gun sound will be managed or reduced based on the proximity of marine mammals to the survey boat. During the survey, a 180-decibel exclusion zone, and an even larger 160-decibel safety zone, will be established around the boat for the protection of marine mammals. The zones were established with help from the National Marine Fisheries Services.

#

14) PG&E expects that there will be marine mammal stranding.

Draft Stranding Response, diablo Canyon, California (PDF Attached)

#

15) Diablo Canyon Nuclear Power Plant is NOT required to protect the "Nation."

https://isearch.avg.com/search?cid={F6FBD5A1-DBED-4A16-AAEC-6CE53E47EE33}&mid=c0caaf6c40b547d6aa7141b2e00444d5-9e62f5f3df670fd2b1ece863d50da82cbe1f4817&ds=AVG&lang=en&v=10.2.0.3&pr=pr&d=2011-09-29%2011:12:48&sap=dsp&q=beached+mammals+from+seismic+testing

U.S. Navy Allowed to Use Sonar That May Harm Whales

Supreme Court Rules in Favor of U.S. Navy

By Jennifer Kennedy, About.com Guide

See More About:

- whales
- cetaceans
- conservation
- sonar

Updated January 16, 2009

In a case of national security once again trumping the environment, the U.S. Supreme Court ruled on November 12, 2008 that the U.S. Navy could continue using high-powered sonar as part of its training exercises, possibly at the expense of whales and other marine mammals. This decision was made in a case of the Natural Resources Defense Council (NRDC) versus the Navy regarding the Navy's use of sonar in training exercises in southern California. The sonar is used to detect enemy ships, and the Navy argued that the sonar is needed to effectively train and protect the nation.

The decision overturns one made earlier in the year by a federal judge in Los Angeles that was upheld by a U.S. Court of Appeals in San Francisco that required the Navy to suspend the use of sonar if it detected a marine mammal within 2,200 yards, and when sea conditions allowed the sonar to travel farther than usual.

# # # # # #

pge2012_diablocanyon_stranding_response_draft.pdf
135K

ITP Goldstein <itp.goldstein@noaa.gov>

Comments - Marine Geophysical Survey off the Central Coast of CA

Jeff Boehm <boehmj@tmmc.org> Fri, Oct 12, 2012 at 10:07 PM
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>
Cc: Marissa Kalashian <kalashianm@tmmc.org>

The attached letter is written in response to the Incidental Harassment Permit filed by PG&E, published in the Federal Register on September 19, 2012.

Thank you,

Jeff

Dr. Jeff Boehm – Executive Director

boehmj@tmmc.org

T: 415.289.7337 | C: 415.686.6062 | F: 415.754.4037

The Marine Mammal Center | 2000 Bunker Road, Fort Cronkhite | Sausalito, CA 94965

www.MarineMammalCenter.org

Adopt-a-Seal!

<image001.jpg>

Adopt a past patient like Garnett and you'll give future patients a second chance at life. ***Adopt-a-Seal today!***

BoehmJ TMMC.pdf
180K

The Marine Mammal Center.

October 11, 2012

P. Michael Payne
Chief, Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

Submission via email to: *ITP.Goldstein@noaa.gov*

Dear Mr. Payne,

This letter is written in response to the Incidental Harassment Permit Application filed by PG&E, published in the Federal Register on September 19, 2012.

The focus of The Marine Mammal Center (TMMC) is to provide a humane response to marine mammals that strand along the 600 miles of coastline in our rescue range, to treat these animals, to perform research to better understand the illnesses that impact them, and to publish and broadly communicate our findings. Every patient that comes into our care is of great importance to our members and to the 1,100 staff and volunteers that comprise our workforce.

We care enormously about any activities that could threaten marine mammals. We also acknowledge that commercial, scientific, governmental and recreational activities occur in waters shared with marine mammals and we support rigorous approaches to the consideration of any potentially harmful operations. Further, we support comprehensive oversight of operations while they are being undertaken and practical mitigation plans that consider a broad array of potential negative impacts.

TMMC advances a robust and productive scientific agenda guided by the presentation of illnesses which we witness in our patient base. We share our findings in peer-reviewed scientific journals. We also objectively provide these publications to those who guide the development of policy and inform public discourse on relevant topics. This approach ensures that the Center maintains a strong, un-biased reputation for our science. While this science does sometimes reinforce positions, we are quite careful as an organization to speak only to issues for which we have significant expertise and/or scientific data. The science around the impacts of seismic activity on marine mammals is only developing and is not a specific area of study for TMMC at this time.

In the context of the destructive impact of the earthquake and tsunami in Japan in 2011, the subsequent loss of human life, and that tragedy's environmental impact, a mandated and increased surveillance and analysis of our coastline's fault lines and risks to power industry

2000 Bunker Road · Fort Cronkhite · Sausalito, CA 94965 · Tel. 415.289.SEAL · Fax 415.289.7333 · MarineMammalCenter.org

Monterey Bay – PO Bo 778 – Moss Landing, CA 95039 – T 831.633.6298 – F 831.633.5927
San Luis Obispo – 1385 Main Street – Morro Bay, CA, 93442 – T 805.771.8300 – F 805.771.8304
Anchor Bay-Fort Bragg – T 415.289.SEAL

infrastructure is underway and is to be expected. A careful and thoughtful approach to this work is essential.

As a non-profit, in existence since 1975, the Center has long enjoyed the diverse support of local corporations, foundations and thousands of individuals in California and, indeed, throughout the United States. Among our corporate sponsors, PG&E has been a leader. The broad support we receive makes our work possible, and clear policies and guidelines ensure that TMMC staff are guided solely by TMMC's mission and our values without undue influence from external supporters.

We have reviewed Appendix F (the Draft Stranding Response Plan) and we're gratified to see that PG&E has been working with The National Marine Fisheries Service to seriously address the issue of marine mammal strandings. We feel the current proposed plan is far superior to the one previously addressed by the California State Lands Commission.

TMMC is the stranding response network group authorized to respond to cetacean strandings in the project area. We note with approval the proposed plan of hiring two people to coordinate surveillance and response. Regarding the active surveillance by a number of groups we would suggest that a more detailed plan be designed and formalized prior to the seismic activities. The longer a stranded cetacean is beached, the lower its chance of survival. Therefore, we believe that the active surveillance plan needs to be designed to have observer coverage during and after active seismic testing in the area, and frequent surveys both from the air and from land in adjacent areas far outside the seismic area as a wounded animal might travel long distances before stranding.

In our community, TMMC has skilled staff and volunteers who stand ready to support the National Marine Fisheries Service's response plan (drafted in anticipation of this proposed work). In the event that there are negative impacts affecting marine mammals, TMMC is specifically prepared to provide rescue, diagnostic, clinical and research support, and to share our findings in a timely way to help mitigate or prevent any further negative effects.

The Center's mission is to advance the conservation of marine mammals, their health, and that of their environment. Our strength lies in our clinical care expertise, our research capacity, and our communication and education programming. We share the public's concern for PG&E's proposed work, and seek to do our part to ensure that the work, if conducted, is carried out in the safest way possible with minimal negative impacts to California's marine mammal populations.

Please contact me if you feel I can provide any further information.

Sincerely,

Dr. Jeffrey R. Boehm
Executive Director

2000 Bunker Road · Fort Cronkhite · Sausalito, CA 94965 · Tel. 415.289.SEAL · Fax 415.289.7333 · MarineMammalCenter.org

Monterey Bay – PO Bo 778 – Moss Landing, CA 95039 – T 831.633.6298 – F 831.633.5927
San Luis Obispo – 1385 Main Street – Morro Bay, CA, 93442 – T 805.771.8300 – F 805.771.8304
Anchor Bay-Fort Bragg – T 415.289.SEAL

ITP Goldstein <itp.goldstein@noaa.gov>

Please Stop Seismic Testing on the Central Coast of California

Dr. Luanne Fose <lfose@calpoly.edu> Fri, Oct 5, 2012 at 12:39 PM
To: itp.goldstein@noaa.gov

Dear Commissioners:

I'm writing to express my opposition to PG&E's Proposal for Seismic Testing on the Central Coast.

This project could have dangerous impacts on ocean ecosystems and recreational ocean users.

PG&E's own EIR clearly states unavoidable impacts to marine life. As an ocean enthusiast, I'm deeply concerned about the impacts to marine life during the testing. California is known for its rich ocean waters and we need to protect every level of our ocean ecosystem from risky and arguably unnecessary projects, such as seismic testing.

I'm also concerned that PG&E is disregarding the health and safety of ocean users. Their EIR clearly says the proposed activities would expose persons present in the water to harmful noise levels. And a recent PG&E map shows that dB levels could reach upward of 160 at some beaches. This is well over the threshold for human safety.

Finally, I'm concerned that PG&E is not analyzing decades of data collected by several sources to paint a full picture of geologic hazards near the power plant, new testing will only provide marginal improvement to what is already known.

Please deny this project. The Coastal Act was created to protect ocean resources and recreation. We believe this project does not conform to following sections of the Coastal Act:

**Section 30220--Protection of certain water-oriented activities-- Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas shall be protected for such uses.

**Section 30224--Recreational boating use--Increased recreational boating use of coastal waters shall be encouraged…

**Section 30230-- Marine resources; maintenance
Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.

**Section 30210-- Access; recreational opportunities; posting
In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs…
We urge you to deny this project and send PG&E "back to the drawing board" in order to protect marine life and ocean users from this unnecessary project.

Thank you in advance for your thoughtful consideration.

Sincerely,

Luanne Fose

Luanne Fose, Ph.D.
Lead Instructional Designer, Academic Technology
Building 35-209B
California Polytechnic State University
1 Grand Avenue
San Luis Obispo, CA 93407

Phone: (805) 756-7360
Email: Lfose@calpoly.edu
Blog & Podcasts: http://www.tweedgeek.com
Cal Poly Web Page: http://www.calpoly.edu/~lfose

"Everybody is a genius. But if you judge a fish by its ability to climb a tree, it will spend it's whole life believing that it is stupid."
~ Albert Einstein

ITP Goldstein <itp.goldstein@noaa.gov>

Marine animals

Susan Goodman <drgoodma@gmail.com> Sun, Oct 14, 2012 at 8:15 PM
To: ITP.Goldstein@noaa.gov

Killing the marine animals is unconscionable. Desist immediately.

Sincerely,
Dr. N.S. Goodman

--
"It is the duty of the peaceful warrior to be unreasonably happy." -Dan Milman

F/PR

Dear Director of National Marine Fisheries Service;
I'm writing to express my opposition to PG&E's Proposal for Seismic Testing off the Central Coast .
As a lifelong sportfisherman, I can recall some 15 to 20 years ago when the DFG did the fish surveys that lead up to the lower bag limits on Rock Fishes and Lingcod, along with the season of only about 6 months out of the year. After all these years, and finally getting some of these fishes back up and going again, and not knowing if it was just a cyclic period, which is very common in nature, or whether the actions by the F&G actually did have the impact on the fishes, now we are faced with the possibility of a near to total wipe-out of nearly everything in the coastal waters, and including the well protected seals, sea lions and otters along a long stretch of this beautiful and bountiful coast. We fishermen and women just feel like all the years we have had to cut back are getting laughed at and thrown under the rug. The fact is that if Mother Nature decides to make an earthquake large enough to do huge amounts of damage, as was the case in Japan a couple years ago, nothing man makes is big enough or sturdy enough to withstand her wrath. Over the life of mankind, it has had to accept and endure those wraths and we will again. Therefore, no testing that could possibly do as much damage as Mother Nature could be worth the risks.
This project could have dangerous impacts on ocean ecosystems and recreational ocean users.
PG&E's own EIR clearly states unavoidable impacts to marine life. As an ocean enthusiast, I'm deeply concerned about the impacts to marine life during the testing. California is known for its rich ocean waters and we need to protect every level of our ocean ecosystem from risky and arguably unnecessary projects, such as seismic testing.
I'm also concerned that PG&E is disregarding the health and safety of ocean users. Their EIR clearly says the proposed activities would expose persons present in the water to harmful noise levels. And a recent PG&E map shows that dB levels could reach upward of 160 at some beaches. This is well over the threshold for human safety.
Finally, I'm concerned that PG&E is not analyzing decades of data collected by several sources to paint a full picture of geologic hazards near the power plant, new testing will only provide marginal improvement to what is already known.
Please deny this project. The Coastal Act was created to protect ocean resources and recreation. We believe this project does not conform to following sections of the Coastal Act:
**Section 30220--Protection of certain water-oriented activities-- Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas shall be protected for such uses.
**Section 30224--Recreational boating use--Increased recreational boating use of coastal waters shall be encouraged...
**Section 30230-- Marine resources; maintenance
Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy

populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.
**Section 30210-- Access; recreational opportunities; posting
In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs...
We urge you to deny this project and send PG&E "back to the drawing board" in order to protect marine life and ocean users from this unnecessary project.
Thank you in advance for your thoughtful consideration.

Sincerely, Ed Coleman, Bakersfield, Ca.

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: FW: Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Howard Goldstein <howard.goldstein@noaa.gov> Mon, Oct 15, 2012 at 7:46 PM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Ed Johnson** <edatthebeach@hotmail.com>
Date: Mon, Oct 15, 2012 at 7:44 PM
Subject: FW: Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012
To: "howard.goldstein@noaa.gov" <howard.goldstein@noaa.gov>, "carol.gallagher@nrc.gov" <carol.gallagher@nrc.gov>, "itp.guan@noaa.gov" <itp.guan@noaa.gov>, "itpcody@noaa.gov.org" <itpcody@noaa.gov.org>

My first attempt;t to submitted this document failed so have added potential reciepients in effort to properly submit, please excuse any unnecessary or redundant addresses used.

From: edatthebeach@hotmail.com
To: itp.goldstein@noaa.govi
Subject: Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012
Date: Mon, 15 Oct 2012 17:31:05 -0600

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

NOAA FISHERIES

Diablo Nuclear seismic Testing.docx
18K

ITP.Goldstein@noaa.gov

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

The following objections have been copied directly from a document submitted by Stand No More Our concerns http://co114w.col114.mail.live.com/default.aspx?wa=wsignin1.0#!/mail/InboxLight.aspx?n=1553465975!n=814693739&fid=1&fav=1&mid=aacd30e3-154a-11e2-9496-00215ad96b9a&fv=1 :

Having read this I completely agree with those assertions listed as follows:

1. Proposal downplays the potential effect on marine life including fish, invertebrates and marine mammals. (I insert the following as evidence of damage caused by seismic airguns and the impact on a major food source of cetaceans http://esciencenews.com/articles/2011/04/11/cephalopods.experience.massive.acoustic.trauma.noise.pollution.oceans titled Cephalopods experience massive acoustic trauma from noise pollution in the oceans. "André and colleagues also found that, immediately following exposure to low frequency sound, the cephalopods showed hair cell damage within the statocysts. Over time, nerve fibers became swollen and, eventually, large holes appeared—these lesions became gradually more pronounced in individuals that were examined several hours after exposure. In other words, damage to the cephalopods' auditory systems emerged immediately following exposure to short, low intensity sweeps of low frequency sound. All of the individuals exposed to the sound showed evidence of acoustic trauma, compared with unexposed individuals that did not show any damage." It is unfortunate that the MMPA protects whales but not their food source though the above article clearly indicates certain species of marine mammals are nearly totally dependent on some invertebrate species for their food; those food sources are not protected.)

2. Important studies that linked seismic surveys to strandings are not mentioned in proposal. Specifically the report by Gentry (2000) called "Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000" is not mentioned, let alone discussed in detail. Report by Malakoff 2002 called "Suit ties whale deaths to research cruise " only mentioned briefly without significant discussion. Other occurrences such as Madagascar stranding are not mentioned at all.

These are documented cases that have not been mentioned in proposal (read more detailed description in our previous post):

1. Mozambique 2006,
2. Gulf of California, 2002
3. Galapagos Islands, 2000
4. Madagascar, 2008
5. Peru, 2012
6. Interesting Statistics from Australia (2002-2004)

3. Crucial study that showed cardiorespiratory changes in beluga whale in response to acoustic noise is not even mentioned in proposal (link). In this study belugas were exposed to noise at much lower level

than is planned in California and the animal demonstrated severe tachycardia "at lower noise intensities (as low as 140 dB);"

4. This proposal is rushed and the levels of impact are not investigated enough and not accessed based on the best scientific evidence available.

5. The company's planned actions lack transparency, they should be required to fully and publicly disclose where activities take place, what equipment will be used, exact Sound Pressure Levels, when activities will take place. Additionally, marine mammal observers logs where they record all marine mammal sightings should be publicly available.

6. The proposal lacks specifics of how strandings will be investigated. It does not include what protocol of stranding investigation will be, what independent organizations will investigate strandings, who and in what manner will look for the evidence of acoustic trauma, decompression sickness related embolism, hemorrhage, etc.

7. NMFS should deny the permit based on omission of the best scientific evidence available and inadequate assessment of impact on marine life."

To your agency, I opposed BP's seismic testing permiting in the following submission

Submitted by Edward Johnson PO box 241 cannon Beach, OR. 97110

ATT: Tammy Adams, Acting Chief, Permits and Conservation Division, of Protected Resources, National Marine Fisheries Service National Oceanic and Atmospheric Administration

RE: Objections to RIN 0648–XY11 Takes of Marine Mammals Incidental to

Specified Activities; Taking Marine Mammals Incidental to Marine Seismic Survey in the Beaufort Sea, Alaska

Within that document further objected to certain provisions related to vessel monitoring

Vessel-Based Monitoring:

- First, the efficacy of observations is generally undetermined. observers will detect a marine mammal that is in a safety zone may be relatively high for some species but low for others, but in no case is the actual efficacy known with a specific degree of confidence.

- Second, observations become less efficient to the point of in no case is the actual efficacy known as sighting conditions deteriorate (e.g., nighttime, high sea state, poor weather).

- Third, visibility is may be adequate for safety zones but the ability to sight animal's declines with distance and disturbance of animals beyond sighting distance may go undetected.

- Fourth, it is difficult to characterize animal responses because observers are not able to focus on animal behavior animals beyond sighting distance may go undetected

- Based on these shortcomings, it is not possible to estimate the number of animals taken with reliable degrees of confidence. In essence, these are not scientifically rigorous surveys, but rather preventative measures of underdetermined efficacy. They should not be used or considered to constitute baseline estimates of the numbers of marine mammals in the area.

- Although there may be no immediate remedy for these shortcomings that can be implemented to improve the utility of vessel-based monitoring, each of the above described shortcomings should be evaluated more closely in the future with the overall aim of characterizing and improving MMO efficiency over time.

The issue of seismic profiling in near shore coastal waters such as those found off the coast of California adjacent to this nuclear facility are unwarranted based on potential damages to all marine life within the proposed testing zone.

Submitted by

Edward W. Johnson

PO Box 241 Cannon Beach,OR.97110

ITP Goldstein <itp.goldstein@noaa.gov>

Public comment on RIN 0648-XC072

Elizabeth Bettenhausen <elizabethbettenhausen@gmail.com> Mon, Oct 15, 2012 at 5:41 PM
To: ITP.Goldstein@noaa.gov

P. Michael Payne, Chief

Permits and Conservation Division

Office of Protected Resources

National Marine Fisheries Service

1315 East-West Highway, Silver Spring, MD 20910

Please see attached letter. Thank you!

EAB to Payne seismic Oct.pdf
248K

Elizabeth Bettenhausen, Ph.D.
345 Plymouth Street
Cambria, CA 93428
elizabethbettenhausen@gmail.com

14 October 2012

P. Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway, Silver Spring, MD 20910
ITP.Goldstein@noaa.gov

RE: RIN 0648-XC072
Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Dear Mr. Payne:

Every week I volunteer with 1st and 2nd graders at the Cambria Grammar School, helping them learn reading, writing, and math. I also tell them about creatures in the ecosystems of ocean, beach, creek, estuary, and forest where we live.

While picking up litter on the beach the other day, I saw dozens of dead pseudoconchs, the planktonic pteropod snail Corolla, washing in at San Simeon State Beach at Santa Rosa Creek. I picked up some samples to show the children.

Last week we explored barnacle shells, include the barnacle that lives only on the gray whale. Last year I actually found that barnacle on the beach. Holding it up after we passed around acorn and gooseneck barnacles on kelp, rocks, and

shells, I ask "Where does this barnacle live?" A photo of the gray whale and barnacles always makes children's eyes open wide. "Wow!"

Yesterday I was reading about sea anemone: "In their natural habitat many sea anemone are calculated to be at least five hundred years old" (A. Rosenfeld, *The Intertidal Wilderness*, Revised Edition, University of California Press, 2002, p. 14). Even the more common age of 60 to 70 years is amazing. I walked then for about three hours along exposed rocks and tide pools before and after low tide. Sea anemone, hermit crab, owl limpet, sea stars, and so much more filled my eyes. At the high tide line snippets of many dead Corolla drew white lines. What shift in current is bringing them to shore?

The beach at Santa Rosa Creek in Cambria and the Morro Bay Estuary are within the area proposed for PG&E's Marine Geophysical Survey. They also lie within protected marine areas established through years of conflict, compromise, and cooperation.

California wisely established the Cambria State Marine Park here. The Monterey Bay National Marine Sanctuary extends south to Cambria off the Central Coast. The San Simeon State Park and Beach extend through Cambria and north. Conservationists attend daily to the land, the water, and the air. Marine protection areas from San Simeon down to Diabolo does penance for the human intervention over centuries that endangered or eliminated so many marine species.

After the 6.5 jolting of the San Simeon fault in December 2003, we take faults and tectonic plates more seriously here. But studying the faults doesn't prevent their movement. The proposal to do seismic testing to get more information about the system of faults in this section of California and the Pacific Ocean confuses information and wisdom. It alleges that the harassment and destruction of marine life is a necessary effect of the testing.

This kind of science won't attract the 1st graders when they're in upper grades and college. Engineering that is ecologically invasive will not make them smile. When respect for the ocean is blossoming, why bloody the waters? A great white shark did interrupt the tagging of the sea otters here the other day. It grabbed a harbor seal that bloodied the waters about 20ft. from a small research boat. The research stopped for the day.

A hungry shark understands ecology, and so do the seals and sea otters. When we humans destroy life as a side effect of doing some research to determine how big the fault line along the coast is, we munch on selfish, exclusive human interests, seasoned with ignorance of reasonable objectives. Increasing the protection of marine life is crucial to human well-being in the near and far term.

The seismic testing is not needed. We know the danger of earthquakes to nuclear plants. Let's do research on reducing our use of nuclear energy.

Thank you for your consideration of my letter.

ITP Goldstein <itp.goldstein@noaa.gov>

Marine Creatures

Elizabeth Hunt <louiselyndon@aol.com> Mon, Oct 15, 2012 at 10:50 AM
To: "itp.goldstein@noaa.gov" <itp.goldstein@noaa.gov>

I have just seen a post on Facebook in rewards to what the Americans would like to do which would cause severe damage to marine creatures. I think this is disgusting and cannot believe this proposal is even being considered.

Regards

Elizabeth Hunt

Ernest Goitein
167 Almendral, Atherton, California 94027

NMFS

August 26, 2012

National Oceanic and Atmospheric Administration
1305 East West Highway
Silver Spring, Maryland 20910

Subject: Proposed Seismic Survey

Dear NOAA,

There appears to be a serious neglect of NEPA requirements to review the proposed seismic survey by Pacific Gas & Electric Company (PG&E). It appears obvious that this proposed survey requires an EIS. In addition it also appears to be a violation of the Marine Mammals Protection Act.

In case you are not aware of the procedures that PG&E is proposing:

> Pacific Gas and Electric Company announced they were going to start seismic testing near their Diablo Canyon Nuclear Plant off the central coast of California by pounding the coast with 240db blasts. These blasts will happen every 63 seconds, around the clock for 42 straight days and nights, starting September 2012.
>
> They admit it will kill about everything in Point Buchon State Marine Reserve, from Great Blue Whales, down to minute larvae, as they blast along a 90 mile stretch of California coast, trying to "prove" the Diablo Canyon Nuclear Plant is "safe", sitting on 3 earthquake faults! Most alarming of all is that the very first two State Marine Reserves ever made (Morro Bay Estuary and Point Buchon) are both already under pressure to be ignored and violated, business as usual. But business as usual will not bring the ocean back to a state of health and abundance, which is the whole purpose of State Marine Reserves.

Currently many humpback whales have been sighted in that area. Time is of the essence. NOAA must act to assure that an EIS is required and that the MMPA is enforced.

Cordially,

Ernest Goitein

RECEIVED
09-28-12
PRI

ITP Goldstein <itp.goldstein@noaa.gov>

Seismic testing off the Central Coast of California

Ernest Goitein <fego@pacbell.net> Mon, Oct 15, 2012 at 3:46 PM
To: ITP.Goldstein@noaa.gov

Dear Mr. or Ms. Goldstein,

I have reviewed the application from the Lamont-Doherty Observatory for an Incidental Harassment Authorization to take marine mammals, by harassment, incidental to conducting a marine seismic survey.

From my reading it is clear that the effect on Marine Mammals from this seismic survey is far more severe than a level B Incidental Harassment Activity. The seismic survey has clearly the potential to injure the whales, dolphins, seals, otters and other marine life off our coast. Therefore Level A harassment is the criteria that should be considered by NOAA.

The reasons for my conclusion is attached.

Cordially, Ernest Goitein

To Noaa = attachment.doc
48K

October 15, 2012

Subject:

Reasons why the Application from the Lamont-Doherty Earth Observatory for a Level B Incidental Harassment Authorization should be rejected.

Discussion:

• The effect of temperature and salinity gradients will tend to act like a lens, propagating the sound horizontally. This would enhance the potential damage to the audio receptors.

• Considering that a dolphin click can table 10 km and the vocalization of some whales can travel 1,000 km, the effects on a much larger population of marine mammals should be considered than is the case in the Application.

• The source sound pressure levels is 236 – 265 dB of each of the 18 air guns being fired simultaneously. The NMFS has stated that potential injury is expected at SPL above 180 dB.

• Many of the studies quoted were done on terrestrial animals – as far as recovery from temporary exposure to high sound levels was concerned. The effects on marine mammals is bound to be more significant as they depend on eco-location and communication. Also the effects tend to by cumulative.

• The energy absorption of sound transmission in water is 0.008 dB/100m. The effects of the air guns will be felt for a much larger area than estimated in the application.

• There is no data on the effect on baleen whales. Instead the language uses words like "assumed" lower sensitivity. Permanent threshold damage is stated to be less likekely to occur. What is the basis for these assumptions?

•

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Please help

Howard Goldstein <howard.goldstein@noaa.gov> Mon, Oct 15, 2012 at 5:41 PM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Ethel Landers** <ethellanders@charter.net>
Date: Mon, Oct 15, 2012 at 5:38 PM
Subject: Please help
To: Howard.Goldstein@noaa.gov

Mr. Goldstein

Please help save thousands of marine animals off the Central Coast of California. Please stop PG&E's seismic testing. We residents know there are earthquake faults near the PG&E nuclear plant. They were there before the plant was built. However killing innocent animals is not the answer. Seismic testing does nothing to improve human safety, and the Harbor Porpoises, Otters and myriads of other creatures could be rendered completely extinct if this unnecessary seismic testing is allowed to go forward.

Please, for the love of God, stop this testing.

Sincerely,

Ethel Landers

1045 La Serenata Way

Nipomo, CA 93444

805 929-1444

--
Howard Goldstein

Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

NOAA FISHERIES

Ladies and Gentlemen,

Please do not permit this ACOUSTIC HOLOCAUST.

The proposed high energy seismic surveys by PG&E's Diablo Canyon nuclear power plant will harass (torment or kill) an estimated 2,830 whales, dolphins and seals in the Morro Bay Harbor. 600 otters, 21% of the population, will be affected. 1,513 porpoises, 75% of the population, will be driven from their feeding and habitat areas. Starfish, shrimp, fish larvae and small species can't swim miles out of range of testing.

These same blasts in Peru earlier this year killed thousands of porpoises. It killed whales by shattering their eardrums and causing brain hemorrhaging. Please consider the fact that grey whales are migrating southward off the California coast during November and December.

How can this seismic testing possibly be justified? New geological information? We know already the Diablo nuclear plant sits on the Hosgri Fault and that 12 En Echelon faults are nearby!

Testing of this magnitude has NEVER been allowed in California waters. Don't allow it now.

Sincerely yours,
Eva Staack-Makela

Eva Staack-Makela

RECEIVED
10-10-12
PRI

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Eveline van den Bossche <evdbossche@home.nl> Sun, Oct 14, 2012 at 6:14 PM
To: ITP.Goldstein@noaa.gov
Cc: "P. Michael Payne" <ITP.Goldstein@noaa.gov>

Sir,

I am sending you this email because of the seismic testing off Californian coast. it is going to cost millions of marine mammals their lives...please will you stop this!

Here is a list of our concerns:

1. Proposal downplays the potential effect on marine life including fish, invertebrates and marine mammals.

2. Important studies that linked seismic surveys to strandings are not mentioned in proposal. Specifically the report by Gentry (2000) called "**Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000**" is not mentioned, let alone discussed in detail. Report by Malakoff 2002 called **"Suit ties whale deaths to research cruise"** only mentioned briefly without significant discussion. Other occurrences such as Madagascar stranding are not mentioned at all.

3. Crucial study that showed cardiorespiratory changes in beluga whale in response to acoustic noise is not even mentioned in proposal (**link**). In this study belugas were exposed to noise at much lower level than is planned in California and the animal demonstrated severe tachycardia "at lower noise intensities (as low as 140 dB);"

4. This proposal is rushed and the levels of impact are not investigated enough and not accessed based on the best scientific evidence available.

5. The company's planned actions lack transparency, they should be required to fully and publicly disclose where activities take place, what equipment will be used, exact Sound Pressure Levels, when activities will take place. Additionally, marine mammal observers logs where they record all marine mammal sightings should be publicly available.

6. The proposal lacks specifics of how strandings will be investigated. It

does not include what protocol of stranding investigation will be, what independent organizations will investigate strandings, who and in what manner will look for the evidence of acoustic trauma, decompression sickness related embolism, hemorrhage, etc.

7. NMFS should deny the permit based on omission of the best scientific evidence available and inadequate assessment of impact on marine life.

I really hope that you will reconsider the seismic testing....it really damages the ocean wildlife and causes many, many deaths of marine mammals.

Thank you,

Eveline van den Bossche
Linda van den Bossche

GRATIS animaties voor je e-mail **Klik hier!**

ITP Goldstein <itp.goldstein@noaa.gov>

no death of mammalian

Flavia ♥ <fla_viaaa@hotmail.com> Sun, Oct 14, 2012 at 7:12 PM
To: itp.goldstein@noaa.gov

no death of mammalian

ITP Goldstein <itp.goldstein@noaa.gov>

Attn: Nonke Mastrup Re: Seismic Testing

Francesca Bolognini <magicalmoon@att.net> Wed, Sep 19, 2012 at 5:36 PM
To: fgc@fgc.ca.gov, Congresswoman Lois Capps <ca23ima@mail.house.gov>, Senator Blakeslee <Senator.Blakeslee@sen.ca.gov>
Cc: ITP.goldstein@noaa.gov, Congresswoman Lois Capps <ca23ima@mail.house.gov>

Dear Nonke Mastrup,

I wish to share several serious concerns regarding the seismic testing proposed for the coastal waters adjacent to Diablo Canyon Nuclear Power Plant.

1. As any competent and impartial geologist will inform you, there is no such thing as an earthquake proof anything. Further, there is also no guarantee, no matter what the outcome of the testing, that an incident registering 9 or above could not happen here. This makes the testing itself an exercise in futility for predicting or preventing catastrophy. They can also tell you that the proposed testing is prone to error, caused by false "reflective areas" within the test zone. What would prevent further fault formation and activity as the result of an event? The only truly safe measure is closure of the plant. The waters off of the Fukushima plant are 50 million times more radioactive than normal. Our situation could be worse. Check with local geologist Lou Blanc on the frequency of tsunami events 50-100' high along this coast. In the last 100 years there have been at least 5. They were written up in the news paper along with accounts of the damage and recovery efforts!

2. 98% of all earthquake energy released in the lower 48 states occurs along the San Andreas fault, which is part of our zone profile. Our zone also lies within a larger formation called the "Ring of fire". This formation, which encircles much of the Pacific Ocean, has experienced historically unprecedented activity in recent years. There have only been a handful of seismic events registering above a 9 on the Richter scale in all of recorded human history. Two of them have taken place on the "Ring of fire" within less than a decade, with catastrophic results. Also, there have been several other underwater volcanic events of unprecedented magnitude even more recently in the area of Australia, and further west, on this formation. Are we next? Plate tectonics was denied until 1965, so our science in this area is still extremely limited. We are taking a huge gamble, at best.

3. Even with the modifications proposed, the testing will have devastating, unavoidable consequences of unknown duration. Tests of a similar nature were done in Norway three years ago and the fish have not yet returned. In Peru, testing caused the deaths of 900 dolphins, who washed ashore. This outcome is completely unacceptable. The damage to innocent wildlife and the long term economic damage to an area dependent on marine tourism, sport fishing and upon the fishing industry for food and income would be much more than we could absorb and hideously immoral.

4. Testing is proposed to include protected marine sanctuary areas. To quote P.J. Webb, attorney and Vice Chair of the Advisory Council of Monterrey Bay National Marine Sanctuary, "Please do not destroy what exists to determine what is already known".

5. If this destruction takes place, the only thing we will know for sure is where oil deposits exist. This, along with the convenient absence of wildlife and ensuing economic collapse, will make our coastline that much more vulnerable to oil interests.

It is my understanding that you are in place to protect us from much of what I have listed here. Please do so, by recommending closure and clean up of the plant, for the sake of our wildlife and the people of the Central Coast.

Francesca Bolognini
P.O. Box 1639
Cambria, Ca. 93428

ITP Goldstein <itp.goldstein@noaa.gov>

RIN 0648-XC072

Fred Collins <fcollins@northernchumash.org> Wed, Sep 19, 2012 at 2:44 PM
To: ITP.Goldstein@noaa.gov

P. Michael Payne, Chief,

Permits and Conservation Division,

Office of Protected Resources,

National Marine Fisheries

Service, 1315 East-West Highway,

Silver Spring, MD 20910.

Dear Sir.

Please find our comments attached concerning PG&E proposed seismic testing.

Be well,

Fred Collins

Tribal Administrator

NCTC Northern Chumash Tribal Council

67 South Street, San Luis Obispo, CA 93401

(805) 801-0347 www.NorthernChumash.org

Educational Services & Environmental Consulting

NCTC Statement of Concerns PGE ST 090212.doc

1733K

Northern Chumash Tribal Council

A Native American Corporation - NorthernChumash.org
67 South Street, San Luis Obispo, CA 93401 805-801-0347

STATEMENT OF CONCERNS AGINST PG&E SEISMIC OFFSHORE TESTING ALONG THE SAN LUIS OBISPO COUNTY COASTLINE
September 17, 2012

The Northern Chumash Tribal Council (NCTC) is a tribal governing body whose members are from San Luis Obispo County and whose members are the living continuum of Chumash Peoples for over 18,000 living along this sacred coastline in San Luis Obispo County, we are **Stakeholders**. NCTC was formed under the guidelines of Senate Bill 18 as a State Recognized Tribal Government. NCTC corporate office is located at 67 South Street San Luis Obispo, CA 93401. NCTC is dedicated to the preservation of Chumash Culture and Heritage, meaningful consulting with local governments, consulting with the development community, and changing government policy for better tribal community well-being.

COMMENTS

AB 1632 requires that as part of PG&E's electricity and natural gas forecasting and assessment activities, to compile and assess EXISTING scientific studies, as specified, to determine the potential vulnerability, to a major disruption due to aging or a major seismic event, of large base load generation facilities of 1,700 megawatts or greater, including a specified analysis of the impact of a major disruption on system reliability, public safety, and the economy. AB 1632 does not require NEW studies. There are low level seismic studies and the onshore seismic studies data that is more than enough to show the connectivity of the faults under the power plant. The proposed seismic studies are not necessary.

Every environmental impact report and environmental impact statement has concluded the environmental devastation would be long-lasting and far reaching. The Environmental Assessment for the Diablo Canyon Seismic project admits "take" or "harassment" will potential cause the death, or torment by permanent deafness, which to a whale, means a slow, lingering death of the partial following mammals list:

Minke whale
Sperm whales
Dwarf sperm whales
Blue whales
Humpback whales
Fin whales
California gray whales
Short-finned pilot whale
Bird's beak
Killer whales,

Striped dolphins
Small beaked whales
Dell's porpoise
Long-beaked dolphins
Rise's dolphins
Northern right whale dolphins
Pacific white-sided dolphins
Bottlenose dolphins
Short-beaked dolphins
Harbor seals
California sea lions
Southern sea otters
Untold sea turtles of several varieties
Numerous fish and bird species
The next generation sea life including nearly billions of larva's of all types

NCTC advocates that the seismic testing be stopped to allow time to thoroughly explore other technologies not harmful to marine life. There is no date collection for science that is worth the possible destruction of the warp and weave of the basket of life.

OFF SHORE SACRED UNREGISTERED CULTURAL RESOURCE SITES

Off shore unregistered Chumash Sacred Sites must be treated the same way on shore Chumash Sacred Sites are treated. No one would let anyone harm the animals that live on or near Chumash Sacred Sites on land, why would anyone allow this to happen off shore. Before any activity that might impact a Chumash Sacred Site mapping and surveying must be done to understand how the proposed activities might affect the Chumash Cultural Resources. All Chumash Sacred Sites must be surveyed and mapped before any project is approved in this sensitive area.

NATIVE AMERICAN FREEDOM OF RELIGION ACT

On and after August 11, 1978, it shall be the policy of the United States to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise the traditional religions of the American Indian, Eskimo, Aleut, and Native Hawaiians, including but not limited to access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites.

The off shore unregistered Chumash Sacred Sites all have great significance for our Chumash Nation, the possibility of having our ancient sites disturbed by seismic blasting would affect the religious significance of the Sacred Sites along our coastline.

The Chumash creation story "The Rainbow Bridge" story talks of how the Dolphins became our ancestors, this is part of which we are, it is a part of our creation story, and it is a magical story for our children growing up receiving great joy from the magic of life.

The potential killing of Dolphins and Whale along with other sea life is not acceptable; any harm would be a violation of the Native American Freedom of Religion Act as these animals are a part of our creation story and our ancestors.

UN DECLARATION OF THE RIGTHS OF INDIGENOUS PEOPLES

Article 19
States shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order obtain their free, prior and informed consent before adopting and implementing legislative or administrative measures that may affect them.

The Northern Chumash Tribal Council does not give consent to cause irreparable harm to the sea life along the San Luis Obispo county coastline. International Treaties are in play because many of the mammals that pass through our coastal water are protected by other international treaties, the entire UN Declaration of the Rights of Indigenous Peoples is in full effect by reference.

CALIFORNIA COASTAL ACT

Section 30230 Marine resources; maintenance Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.

The potential harm to any sea life would be a violation of the California Coastal Act.
The location of the survey area sits between two National Marine Sanctuaries and has itself qualified for National Marine Sanctuary Designation since 1990. The sonic blasts will be too intense at 250 decibels for marine life to remain viable. The entire marine web-of-life will be destroyed.

Sanctuaries provide enhanced safeguards for species within their boundaries, a protection that is lost when they leave. Other protected areas along or at the terminus of a migration route or that cover areas for important life stages of living marine resources (e.g., nesting areas for seabirds, pupping areas for seals, fish spawning aggregation sites, larval dispersal and sink sites), provide the same kind of enhanced protection. Forming relationships and developing joint projects among countries with areas of biophysical connectivity will increase the protection to these often endangered and otherwise vulnerable species.

These resources are extremely important for our coastal communities to grow into the future, we are protecting them, please assist us in not destroying our priceless resources.

AVIAL BEACH AND MORRO BAY FISHING INDUSTRY

The coastal communities are not prepared for this ocean disaster that will end commercial fishing for an unknown length of time. The Morro Bay and San Luis Harbor fishermen have

worked for decades to create sustainable locally "branded" fishing. They now stand to lose their livelihoods. There is no mitigation for returning the fish and their web-of-life. All things are tied together and the effects of seismic testing along the coast are not in the best interest of the people who live here and who have lived here for over 18,000 years.

MARINE PERTECTION AREAS
MPA

(1) To protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.
(2) To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.
(3) To improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity.
(4) To protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value.

The destruction of our MPA's after we have spent so many years working to protect them and now when they are working with the other environmental programs in place to bring back our local fisheries it is not the time to destroy them but it is the time to protect them for the future generations. We the Native Community understand that it is vitally important to make decision that look out into the future 7 generations, only then are you truly making sound decisions. There is no sound decision making in this project, it is completely out of balance with all the elements of life. This project must be looked at as a whole not as just the data that will be collected, that is a very small part, the bigger picture is the environment, to get a small percentage of data at the sacrifice of a potential large sacrifice of sea life is not acceptable.

The Northern Chumash Tribal Council stands to protect our Sacred Land and our Culture, please assist us in our stand for dignity and peace with the Sacred Heritage of our land as we attempt to protect our culture for future generations to come.

Thank you for the opportunity to comment.

Elders Council
Northern Chumash Tribal Council

ITP Goldstein <itp.goldstein@noaa.gov>

(no subject)

you-cant-sink-a-rainbow@gmx.net <you-cant-sink-a-rainbow@gmx.net> Sun, Oct 14, 2012 at 5:32 PM
To: ITP.Goldstein@noaa.gov

STOP KILLING WILDLIFE!!!

G. Becker
Germany

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd:

Howard Goldstein <howard.goldstein@noaa.gov> Mon, Oct 15, 2012 at 7:32 PM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Gayle Mcc** <gaylemcc77@yahoo.com>
Date: Mon, Oct 15, 2012 at 7:31 PM
Subject:
To: "howard.goldstein@noaa.gov" <howard.goldstein@noaa.gov>

Mr. Goldstein, Because the staging parts of this project having been allowed to go ahead without the peoples input or a complete regulatory process, the baselines are shifted, and no study results will be trustworthy or accurate.Also, the whales are endangered already, and don't need to be harassed or worse. And because PG&E has stated they will make no plant upgrades regardless of the seismic results, seismic testing does nothing to improve our safety. Finally, this area being the core home of the species, Harbor Porpoises and Otters could be rendered completely extinct if this unnecessary seismic testing is allowed to go forward.
thanks you,
Gayle McClain

Sent from Yahoo! Mail on Android

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

ITP Goldstein <itp.goldstein@noaa.gov>

testing on the central coast

Geri Ragan <gerproud@aol.com> Mon, Oct 15, 2012 at 4:08 AM
To: ITP.Goldstein@noaa.gov

This testing is absolutely crazy... Have they thought about how much sea life will wash ashore on our beautiful coastline? Or how about the unknown injured animals that will be in need of assistance. What do they plan to do for that? This is unnecessary testing. I oppose any type of testing that endangers any sea creatures life. I hope to take part in any protests to support our cause to save these lives.

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Stop the Seismic Testing at Diablo Power Plant

Howard Goldstein <howard.goldstein@noaa.gov> Tue, Oct 16, 2012 at 9:06 AM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Gina Whitaker** <uuspirit@me.com>
Date: Mon, Oct 15, 2012 at 11:46 PM
Subject: Stop the Seismic Testing at Diablo Power Plant
To: Howard.Goldstein@noaa.gov, joseph.sebrosky@nrc.gov

Dear Mr. Goldstein and Mr. Sebrosky,
Do you realize what a state we are in here as a result of planned seismic testing off the coast at the Diablo Nuclear Power Plant?

If you have any ethics at all, you will stop this seismic testing, if for no other reason than to preserve the ability of our community to communicate at all with each other. There is a wave of confusion and controversy that is rolling over our towns and cities like a tsunami of fear and desperation.

But there are other reasons...The baselines have been shifted, the whales are endangered already, seismic testing does nothing to improve our safety, and the Harbor Porpoises and Otters could be rendered completely extinct if this unnecessary seismic testing is allowed to go forward.

I am not going to try to site the overwhelming body of information that has been flowing daily here in SLO County that shows how dangerous this testing can be for our wildlife, or convince you based on some specific paper or study. You are as aware as anyone of those studies and papers. Suffice it to say, if this testing goes forward, I fear we will have human deaths of people who are so committed to saving these marine mammals that they will enter the water and strap themselves to the nearest whale or seal...not me, for sure, but there will be some.

Our love for this coastline and the overwhelming beauty of it, it's natural inhabitants--the animals of the sea and land--is strong. Please help us come together again as a community and find another way to deal with a power plant built on at least 14 earthquake fault lines. We must maintain safety for our citizens but NOT at the expense of our animal beings, and I do not believe we will gain safety through this testing.

We are ALL a part of a interconnected web, and we have a moral responsibility to protect it. You, too.

In faith,
Gina Whitaker
Arroyo Grande, CA

--

Howard Goldstein

Fisheries Biologist

NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

NOAA FISHERIES

ITP Goldstein <itp.goldstein@noaa.gov>

I am opposed to using PGE's oil exploration airguns to locate seismic faults at Diablo Canyon, California

Ginnie Gregg <ginnie.michael@gmail.com> Fri, Oct 12, 2012 at 11:24 AM
To: ITP.Goldstein@noaa.gov

I have heard of other less invasive methods of locating seismic faults including sensors for earth's magnetic field & creating actual shaking underwater. We are looking for trouble if we disrupt the Diablo Canyon area further. That wretched nuke plant is bad enough without damaging marine life up and down the Coast.

Ginnie Gregg, Tehachapi, CA
ginnie.michael@gmail.com

ITP Goldstein <itp.goldstein@noaa.gov>

Marine mammals

giovanna salvatore <gigi.oliveira123@hotmail.com> Mon, Oct 15, 2012 at 1:32 PM
To: itp.goldstein@noaa.gov

Hello, I'm from Brazil, I'm only 13 years old, but I have come to beg an important thing for me and for all who care about the future of humanity: Do not kill marine mammals! They are part of nature. Of course you must have reasons for doing this, but we have much knowledge of new technologies, and even kill those who are in harmless? Please, I beg you, even as a child.

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Please cancel seismic testing for the Central Coast of California.

Howard Goldstein <howard.goldstein@noaa.gov> Tue, Oct 16, 2012 at 9:05 AM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Guloim Zhapbarbergenoa** <suoress@gmail.com>
Date: Mon, Oct 15, 2012 at 10:38 PM
Subject: Please cancel seismic testing for the Central Coast of California.
To: howard.goldstein@noaa.gov

Dear Mr. Goldstein,

Because the staging parts of this project having been allowed to go ahead without the peoples input or a complete regulatory process, the baselines are shifted, and no study results will be trustworthy or accurate.Also, the whales are endangered already, and don't need to be harassed or worse. And because PG&E has stated they will make no plant upgrades regardless of the seismic results, seismic testing does nothing to improve our safety. Finally, this area being the core home of the species, Harbor Porpoises and Otters could be rendered completely extinct if this unnecessary seismic testing is allowed to go forward.

Signed,

Guloim Zhapbarbergenova

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

ITP Goldstein <itp.goldstein@noaa.gov>

(no subject)

Harvey Cohon <harveyandkathy@yahoo.com> Sun, Oct 14, 2012 at 6:31 PM
Reply-To: Harvey Cohon <harveyandkathy@yahoo.com>
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>

P. Michael Payne
Chief Permits & Conservation Division
Office of Protected Resources
1315 East-West Highway
Silver Spring, Md. 20910
Regarding the use of sonic testing for 3D views of Diablo Canyon I recently reviewed this enclosed subject.

http://www.bluevoice.org/news_perudolphins.php

Please stop this type of testing till we have a less harmful method available.

Harvey Cohon

BREAKING NEWS

DOLPHINS

WHALES

KILLER WHALES

SHARKS

OCEAN ISSUES

BLUEVIEWS BLOG

MEDIA CENTER

WEBFILMS

PODCASTS

DOLPHIN DEFENDER

WATCH A PREVIEW

< Dolphins

Massive Die-off of Dolphins in Peru

The Peruvian government has released a report on the mass mortality of at least 900 dolphins along the coast of Peru that states that “natural causes” and “evolutionary forces” were the cause of death.

BlueVoice, which has funded extended and extensive research conducted by Peruvian veterinarian and marine mammal expert Dr. Carlos Yaipen Llanos, believes that conclusion is nonsense. We present here a narrative history of the mortality event and Dr. Yaipen Llanos’ hypothesis that acoustical trauma followed by rapid ascent leading to catastrophic decompression is the most likely cause of death. Dr. Yaipen Llanos makes no assertion that seismic testing for oil is associated with the dolphin mortality. However BlueVoice suggests that this form of extremely loud testing makes the seismic tests a primary “element of interest”. Seismic testing was taking place in approximately the same time frame and geographical location as the dolphin mass mortality.

We stress that Dr. Yaipen Llanos has made no assertion that the mass mortality event was caused by seismic testing by oil companies.

It should be noted that some highly regarded experts who question Dr. Yaipen Llanos’ conclusion of acoustical trauma/decompression syndrome, freely admit that they have very little information to assess. Neither do they have an alternative hypothesis.

Hardy & Carlos w/ dead baby dolphin

The Story As Seen By Hardy Jones Of Bluevoice.Org And Dr. Yaipen Llanos Orca Peru.

During February 2012 rumors began circulating that hundreds of dolphins were dying along the northern coast of Peru. But the beaches are remote and no one had actually confirmed the rumors and certainly not made a reconnaissance. BlueVoice Executive Director Hardy Jones flew to Peru where he joined Dr. Carlos Yaipen Llanos of the marine rescue organization ORCA. In order to verify the number of dolphins stranding on the northern beaches of Peru they traveled north from Chiclayo/San Jose. They counted 615 dead dolphins in 135 kilometers. They thus verified that the die-off that had been rumored was a tragic reality.

BlueVoice has funded an ongoing investigation into the cause of the mortality, supporting Dr. Yaipen Llanos in his efforts to necropsy as many dolphins as possible. Here are the results of his investigation.

Initial conclusions from research on dolphins stranded in northern Peru:

Dolphins died due to acoustical trauma and decompression syndrome.

Background:

• Between March 26th and April 26th, 2012, in a coordinated effort with the Peruvian Ecological Police, ORCA and BlueVoice.org made several expeditions to the "Stranding Zone", covering up to 135 km of deserted beaches and confirming the largest mass stranding of dolphins ever in South America.

Hardy views necropsy

To verify that the information on the stranding was correct, Dr. Yaipen-Llanos and Jones joined in a scientific investigation into the cause of death of the dolphins. Successive expeditions during the month of April confirmed continuation of the mass stranding and expanded the number of visually confirmed dolphin deaths to 747.

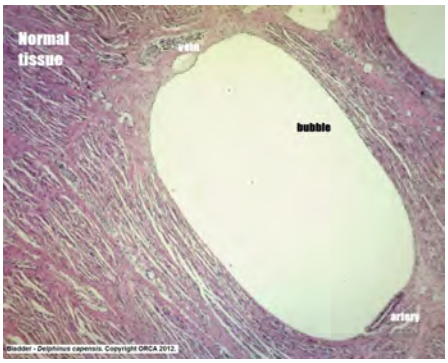
In addition, on April 27th 2012, ORCA confirmed that dolphins are still being hunted and eaten by fishermen. BlueVoice will report further on this.

In that week, decaying carcasses continued beaching on the "stranding zone."

The affected species found in all the expeditions were:

• Long-beaked common dolphin (Delphinus capensis) - 91% of stranded animals.
• Burmeister's porpoise (Phocoena spinipinnis) - 9% of stranded animals.

FINDINGS

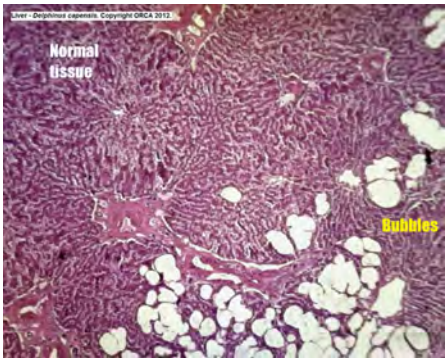


Dolphin bladder - huge bubble compressing vein & artery

• The necropsy procedures and report that ORCA uses for sampling, macroscopic and microscopic analysis is established for marine mammals by the U.S. National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife United States (FWS).

• To perform research and analysis of samples, ORCA implemented a Diagnostic Laboratory
• ORCA performed 30 necropsies taking into account the degree of decomposition and the viability of samples for diagnostic purposes. The necropsies were performed on the beach since the full body of the dolphins could not be transported. Fresh and viable samples were collected as quickly as possible – always a priority in marine forensics.
• The necropsy included examination of general body condition, injuries, or external malformations, natural cavities, abdomen, chest, neck and head.
• To prevent misdiagnosis, we used soft tissues of those bodies in fresh condition in order to have a clear view of the cellular structures and identify lesions in the tissues.
• We found that stranded dolphins had the following signs:

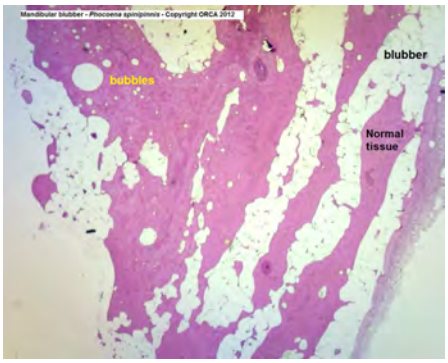
a. Bleeding in the middle ear.



Dolphin liver - bubbles are replacing normal tissue

b. Simple fracture and cracks in the middle ear (periotic) bones.
c. Hemorrhage and bubbles in mandibular fat (where dolphins perceive incoming sounds)
d. Massive invasion of air bubbles which displaced the normal tissue of vital organs such as lungs, liver, kidney, bladder and blood vessels.
e. Pulmonary emphysema: air bubbles, bleeding and massive destruction of lung tissue.

According to these medical findings, the dolphins suffered from acute decompression syndrome that produced injures associated with acoustic impact.



Mandibular blubbler of baby porpoise - bubbles spreading in the normal tissue, plus blood vessels are congested and hemorraghic

In the case of this unusual mortality event, only two cetacean species were affected because only these two species were in the range of the potential sound wave, which was released in several distinct moments that translated into a long period of time over which the dolphin die-off occurred. The presence of both long beaked common dolphins and Burmeister's porpoises in the ocean surface is associated with the seasonality of each species. While 37 species of cetaceans live in Peru, these are not found in one place at the same time, but spread throughout the year in different areas of the ocean.

The dolphins and porpoises died in a focalized area. They all died off shore. They did not die at the same time. However, all the dolphins that went through forensic analysis produced the same medical findings which indicates that the cause of death was not produced once, but multiple times and in very distinct moments while the dolphins were in the area. This was possible to assess through the condition of the carcasses that correlate the strandings to a long period of time. No strandings of dolphins outside the "stranding zone" were found with similar findings.

DISCARDED CAUSES OF DEATH

• VIRUS: None of the stranded dolphins showed external signs of viral disease. Internally, none of the necropsied dolphins had findings consistent with viral disease in their bodies. In the case of viral diseases, when they cause the death of the animal, they must necessarily produce a "viremic phase" or signs of infection with macroscopic and microscopic typical clinical picture of the disease, which was not found in dolphins reviewed. We did not find fluid in the lungs (edema), or intestinal necrosis or hyperplasia in the bladder, plus there was a notable absence of the typical viral inclusion bodies.

If the case of a viral infection, especially if it was Morbillivirus, strandings would have occurred in larger quantities and would affected a larger number of marine mammals species, sparking a pandemic alert as it happened in other unusual mortality events associated with this virus.

• ILLNESS: We found no signs consistent with bacterial diseases or poisoning affecting the digestive system.

• Starvation: It is not possible that the beach stranded dolphins died from starvation because the bodies show good fitness (subcutaneous fat present) and no stomach damage or gastritis was found as is associated with prolonged fasting.

• THE EVENT OF BIRD DEATHS IS INDEPENDENT OF THE DOLPHIN UNUSUAL MORTALITY EVENT

• So far there is no virus that could pass or transfer zoonotically from marine mammals to birds in the area.
• Where acoustic impact is the cause of death of dolphins, this impact does not occur in birds because they handle different sound frequencies and they spend little time with their heads underwater.

PERU AND DOLPHIN CONSERVATION

• 40% of known cetacean species in the world transit through Peru.
• Over 90% of deaths of dolphins in Peru are caused by human aggression/interaction.
• The stranding of dolphins in Peru during the first quarter of 2012 is a warning. On this occasion the impact was on dolphins and porpoises. It would have been other species or whales at another time of year.
• The Congress of Peru has the opportunity to enact the Law 4248 for Animal Protection and Welfare to strengthen mechanisms to protect dolphins and animals from human impact. Currently, this law has been filed in the Congress and is awaiting disposition.

We can do a Spanish version of Carlos press release

Photos
Necropsy microphotos

BlueVoice.org is a non-profit 501 (c) (3) organization registered with the U.S. Internal Revenue Service.
© Copyright 2000-2007 BlueVoice.org. All contents, including the BlueVoice.org logo, are copyright BlueVoice.org
All rights reserved. Website design by Troika Studio

Howard Goldstein <howard.goldstein@noaa.gov>

Fwd: The Diablo Canyon Air-Cannon Survey - It's All About The Oil

Helen Golde <helen.golde@noaa.gov> Tue, Oct 2, 2012 at 3:45 PM
To: Brian Bloodworth <brian.bloodworth@noaa.gov>, Howard Goldstein <howard.goldstein@noaa.gov>
Cc: Jolie Harrison <jolie.harrison@noaa.gov>, Gina Shultz <gina.shultz@noaa.gov>, Therese Conant <therese.conant@noaa.gov>

---------- Forwarded message ----------
From: **Harvey Sherback** <harveysherback@yahoo.com>
Date: Tue, Oct 2, 2012 at 2:58 PM
Subject: Re: The Diablo Canyon Air-Cannon Survey - It's All About The Oil
To: Helen.Golde@noaa.gov

National Marine Fisheries Service
Helen M. Golde
Acting Director - Office of Protected Resources

October 2, 2012

Hello Helen,

Thanks for your many good works. I send the attached letter to the California Fish & Game Commission. It's really all about offshore oil and gas drilling in California. The petroleum industry wants to drill baby drill.

The best,

Harvey Sherback

--

California Fish and Game Commission
Commissioners
Jim Kellogg
President

September 21, 2012

Dear President Kellogg, California Fish and Game Commissioners & Staff,

Your many efforts in protecting California's wildlife are very much appreciated. The attached letter outlines the "real problem" with the Diablo Canyon Air-Cannon Survey.

Harvey Sherback
Berkeley, California

--

Helen M. Golde
Acting Director
NOAA Fisheries
U.S. Department of Commerce
Office: 301-427-8400
Mobile: 240-429-0344
helen.golde@noaa.gov
www.nmfs.noaa.gov/pr/

Coastal Commission Letter.doc II.doc
27K

The California Fish and Game Commission
Commissioners
Jim Kellogg
President

September 21, 2012

Dear President Kellogg, California Fish and Game Commissioners & Staff,

Thanks for your many good works. At the September 14, 2012 meeting of the California Coastal Commission, Deputy Director Alison Dettmer announced that the Diablo Canyon air-cannon survey would cover about 300 square miles including state and federal waters. The seismic testing is expected to kill and injure a large variety of already endangered sea life, including California Gray Whales, Dolphins, Porpoises, Harbor Seals, California Sea Lions and Southern Sea Otters. This testing campaign will also negatively impact untold numbers of sea turtles, fish and bird species, while devastating their larvae and subsequent generations of sea life. This is the wrong direction for California. In 1936, the Gray Whale became a protected, endangered species in U.S. waters. Part of this devastating assault on wildlife will take place in the "protected" Point Buchon State Marine Reserve.

On September 14, Deputy Director Dettmer revealed that there would be second seismic survey carried out near the San Onofre nuclear plant. Until then, the public had no idea that another, much larger, high-energy offshore survey was in the works. The San Onofre survey would be conducted in federal waters that would cover approximately 1,300 square miles. Both the Diablo Canyon and the San Onofre seismic surveys will add up to a total of 1,600 square miles. This expansion will lead to a fourfold increase in the number of marine creatures that will be seriously injured and killed.

As we already know, the aging Diablo Canyon and San Onofre nuclear power plants are sitting on and near several major fault-lines located within California's "Ring of Fire" earthquake zone. The multiple air-cannon underwater blasts used in the proposed testing will create explosive shock waves. This explosive testing methodology could itself trigger earthquakes. There are over 247 "identified" fault systems in the State of California, but in truth, there are just too many fault lines to count. In addition, there are also the thousands of collaterals, which are faults that branch off major fault lines. California is earthquake country, there's no denying it!

The proposed testing may not gather the information it claims to seek. According to Jeanne Hardeback, a research geophysicist with the United States Geological Survey's earthquake hazards team, the seismic maps would do little to reveal the likelihood of an earthquake causing rupture. The proposed seismic surveys do not measure the speeds at which underlying tectonic plates are slipping past each other. The speed of tectonic movements can be recorded by placing an array of global-positioning devices on the ocean floor, and since no such devices will be used in these tests, the results of PG&E's proposed seismic survey will be non-conclusive regarding earthquakes.

I am concerned about a serious conflict of interest motivating these studies. Shouldn't an expert on earthquakes be running this survey or is this test designed for a different purpose? This form of testing is more appropriate for petroleum exploration than seismic analysis, and offshore petroleum extraction appears to be Deputy Director Dettmer's area of expertise.

I believe this testing program is designed to create an extensive three-dimensional offshore seismic map for the purpose of locating marine oil and gas deposits, all at the utility ratepayer's expense. On September 13, 2012 the California Public Utilities Commission approved PG&E's request to pass along the $64 million cost of the Diablo Canyon surveys to its customers. That's right, Pacific Gas and Electric Company customers will be paying for a large part of Deputy Director Dettmer's offshore oil and gas survey!

The following is a 1992 Summary Report coauthored by Alison Dettmer.

Title: California Offshore Oil And Gas Development

Authors: Alison Dettmer, Charles Lester, Energy and Ocean Resources Unit, California Coastal Commission

Publisher: California Coastal Commission, July 1992

Length: 103 pages

Subjects: Technology & Engineering › Petroleum

Natural gas in submerged lands
Petroleum in submerged lands
Technology & Engineering / Petroleum

The energy companies would love to harvest California's offshore oil and gas deposits, and obtaining ratepayer sponsored seismic maps of California's marine coastline is pure gold to the extraction industry. Is this study the first step towards justifying drilling and fracking off our coastline?

Please do not proceed with these tests as planned. The evidence does not support the need for these surveys, and we must instead develop plans to close both the Diablo Canyon and San Onofre nuclear plants. Closing these aging and potentially dangerous power plants will help protect California's future by insuring the quality of our coastline, our marine life and our fishing and farming economies.

Harvey Sherback
Berkeley, California

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Heather H <heatherhintz1@yahoo.com> Mon, Oct 15, 2012 at 12:52 PM
To: ITP.Goldstein@noaa.gov

To:
P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine

Dear Mr Payne,

Seismic testing can kill thousands of dolphins & whales, because they are very sensitive for sound! We must avoid such slaughter. Seismic testing MUST stop!

Proposal downplays the potential effect on marine life including fish, invertebrates and marine mammals.

2. Important studies that linked seismic surveys to strandings are not mentioned in proposal. Specifically the report by Gentry (2000) called "**Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000**" is not mentioned, let alone discussed in detail. Report by Malakoff 2002 called **"Suit ties whale deaths to research cruise"** only mentioned briefly without significant discussion. Other occurrences such as Madagascar stranding are not mentioned at all.

Please take my comments into consideration when making your decision to harm or not harm thousands of marine animals.

Thank You!

Heather Hintz

ITP Goldstein <itp.goldstein@noaa.gov>

PG&E proposed HESS

hunter kilpatrick <defanhk@sbcglobal.net> Wed, Sep 19, 2012 at 2:23 AM
Reply-To: hunter kilpatrick <defanhk@sbcglobal.net>
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>

The proposed HESS by Pacific Gas and Electric for November-December should be denied a take permit. At the very least it is a matter that should be postponed and revisited in at least a year. While I understand the need for a thorough understanding of the potential seismic events around Diablo Canyon, there is an abundance of data that has already been gathered and needs to be evaluated before the proposed HESS. The need for a "take" permit for Level B take is at this time unnecessary and will at best be to gather redundant information and data and therefore an avoidable situation that should not be allowed to take. The FEIR on the proposal itself expects up to 5000 marine mammals to be at the very minimum disrupted and although the direct link from seismic surveys to strandings and disorientation of mammals is very hard to prove, it is a risk that is too great at this time. As a marine mammal observer, informal educator and member of the local rescue agency I know at the time of these test, we still have occasional humpback whales, early grey whales are here on their annual migration south (I have seen on several occasions mom/calf pairs going south from early births), elephant seals are on their migration to the channel islands and we have thousands of resident porpoises, dolphins, harbor seals, california sea lions and sea otters.
I believe strongly that after all current data is reviewed and analyzed it will be deemed unnecessary to further test and therefore the need for incidental take at this time is invalid.
Thank you
Hunter Kilpatrick

ITP Goldstein <itp.goldstein@noaa.gov>

PGE HESS comment submission

hunter kilpatrick <morrobayhunter@yahoo.com> Fri, Oct 12, 2012 at 12:22 AM
Reply-To: hunter kilpatrick <morrobayhunter@yahoo.com>
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>
Cc: Sue Arnold <suearnold@linknet.com.au>

P. Michael Payne 11/10/2012
Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, Md. 20910

Mr. Payne,
Enclosed you will find our submission along with documents supporting photographic identification of Western Gray's, the ACS/LA census data for December 2007-2011 and an article from the International Society for Comparative Psychology (emailed only – it's a big one) on the effects of noise on marine mammals and other animal. We also are submitting this submission by hard copy via regular mail.

Please feel free to contact me if you would like any information clarified or would like more data on any issue of this.

Sincerely

Hunter Kilpatrick

Hunter Kilpatrick
Central Coast Director
California Gray Whale Coalition
(805) 772-7501

cc: Sue Arnold - Executive Director CGWC

5 attachments

ijcp-20-2-3.pdf
5711K

cover letter to nmfs.pdf
244K

Submission to NMFS PGE HESS.pdf
547K

WESTERN GRAY WHALE MIGRATION.pdf
172K

Pt. Vicente GW Census Data (Dec) 2007-2011.pdf
136K

PHOTOGRAPHIC COMPARISON OF THE WESTERN AND MEXICAN GRAY WHALE CATALOGUES: 2012.

J. Urbán R.[1], D. Weller[2], O. Tyurneva[3], S. Swartz[4], A. Bradford[5], Y. Yakovlev[3], O. Sychenko[6], H. Rosales N[1]., S. Martínez A[1]., A. Burdin[6] and A. Gómez-Gallardo U.[1]

[1] *Programa de Investigación de Mamíferos Marinos. Universidad Autónoma de Baja California Sur, La Paz, B.C.S., Mexico*

[2] *Protected Resources Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 3333 North Torrey Pines Court, La Jolla, CA, 92037-1022 USA*

[3] *A.V. Zhirmunsky Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, 690041, Russia.*

[4] *Laguna San Ignacio Ecosystem Science Program, Darnestown, MD, USA*

[5] *Protected Species Division, Pacific Islands Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Honolulu, HI, USA*

[6] *Kamchatka Branch of Pacific Institute of Geography, Far East Branch - Russian Academy of Sciences, Petropavlovsk, Kamchatka, Russia*

ABSTRACT

Photographs of 217 identified gray whales obtained from the Sakhalin Island, Russia feeding grounds were compared with 6,546 photo-identified individuals from the Baja California Peninsula, Mexico breeding lagoons to identify matches between these two populations. A total of 14 matches of individuals were found, including six males, six females and two of unknown sex. Thirteen whales had sightings prior to and after to their respective sighting in Mexico. Thirteen whales were observed in Laguna San Ignacio and one in Laguna Ojo de Liebre. Eleven of the 14 whales were photographed in Mexico only in one year and the other 3 in two years. Thirteen whales were sighted in Sakhalin in the summer of 2011. Twelve whales were sighted in consecutive seasons, eight of them in three consecutive seasons (summer-winter-summer), three in two seasons (summer-winter), and five in two seasons (winter-summer). Three whales were sighted the same day in Laguna San Ignacio suggesting that these animals were traveling in association with each other. Five females with calves were sighted in the winter in Mexican waters and in the next summer off Sakhalin, three of them without calves suggesting that these females had either separated from their calves or that their calves did not survive. The time between the last sighting in one season and the first one in the next season was $\bar{x}=195.4$ days (n=11, 141-255) during the summer-winter migration, and $\bar{x}=165.6$ days (n=13, 131-213) during the winter-summer migration. The matches made between whales sighted off Sakhalin and the Mexican Pacific are the first results of the multinational collaboration "PACIFIC WIDE STUDY ON POPULATION STRUCTURE AND MOVEMENT PATTERNS OF NORTH PACIFIC GRAY WHALES" initiated under the coordination and support of the International Whaling Commission last year.

INTRODUCTION

Recent results of genetic and photographic identification comparisons between western and eastern North Pacific gray whales (see IWC, 2011) suggest a mixing of these populations during the winter reproductive season, and illustrate the great conservation and management importance of a more comprehensive examination of gray whale movement patterns and population structure in the North Pacific. The Scientific Committee recommended that a collaborative Pacific-wide study be developed under the auspices of the IWC, recognising that *inter alia* this will contribute to the Committee-

endorsed Conservation Plan for western North Pacific gray whales and incorporate previous recommendations made by the Committee. Such a study will involve collaborative analysis and sharing of existing data as well as the collection of new data. This report summarizes the results of the "(Phase 1) photo-identification project". The purpose of this project was to undertake a comparison of two western gray whale catalogues from Sakhalin Island, Russia with the Mexican gray whale catalogue.

METHODS

The comparison was done based on two catalogues of photo-identified gray whales from Sakhalin Island and one catalogue of gray whales from Laguna San Ignacio and Laguna Ojo the Liebre on the west coast of the Baja California Peninsula, México.

The Sakhalin catalogues

The first step was to compare the two catalogues available at that moment:

1) The Russia-US catalogue (2012).

Burdin, A. M., Weller, D., Sychenko, O., and Bradford, A. 2012. *"WESTERN GRAY WHALES OFF SAKHALIN ISLAND, RUSSIA: A CATALOG OF PHOTO-IDENTIFIED INDIVIDUALS"*.
205 individuals. Period 1994-2011
2) The IBM catalogue.

Tyurneva, O. Yu. and Yakovlev, Yu. M. 2010. "THE WESTERN PACIFIC GRAY WHALES OF SAKHALIN ISLAND 2002-2008, LEARING ABOUT A POPULATION OF WHALES THROUGH PHOTOGRAPHS".
165 individuals. Period: 2002-2008

As result of these comparisons 217 photo-identified gray whales from Sakhalin were used in the comparison with the Mexican catalogue. All are represented by the right-side dorsal flank and 215 are associated with the left-side dorsal flank

The Mexican catalogue

This catalogue includes 6,546 gray whales. 5366 photo-identified in Laguna San Ignacio between 1993 and 2011, and 1180 in Laguna Ojo de Liebre (Scammon´s Lagoon) between 2001 and 2003. Of the 6,546 whales in the catalogue 5,890 are represented by a right-side of the dorsal flank image and 1,837 were associated with a left-side dorsal flank image (Table 1).

Table 1. Number of photo-identified gray whales in the Mexican catalogue.
Laguna Ojo de Liebre = LOL, Laguna San Ignacio = LSI.

year	Total photo-id whales	Right and left sides	Only right side	Only left side	Lagoon
2001	398	0	398	0	LOL
2002	462	0	462	0	LOL
2003	320	0	320	0	LOL
1996	157	0	155	2	LSI
1997	310	0	310	0	LSI
1998	392	0	392	0	LSI
1999	253	0	253	0	LSI
2000	448	0	448	0	LSI
2003	247	0	247	0	LSI
2005	438	18	420	0	LSI
2006	249	22	226	1	LSI
2007	495	150	217	128	LSI
2008	358	114	137	107	LSI
2009	662	286	238	138	LSI
2010	750	250	319	181	LSI
2011	607	341	167	99	LSI
Total	**6546**	**1181**	**4709**	**656**	

RESULTS.

The Sakhalin to Mexico catalog comparison resulted in a total of 14 confirmed matches of individuals, including six males, six females and two of unknown sex. Thirteen whales had sightings prior and after to their respective sighting in Mexico. Twelve whales were observed in Laguna San Ignacio and one (#3) in Laguna Ojo de Liebre. Eleven of the 13 whales were photographed in Mexico only in one year and the other 3 in two years. Thirteen whales were sighted in Sakhalin in the summer of 2011(Table 2).

All fourteen whales were sighted in consecutive seasons, eight of them in three consecutive seasons (summer-winter-summer), three in two seasons (summer-winter), and six in two seasons (winter-summer). Whale #2, male, was sighted in summer-winter (2006-2007), and summer-winter-summer (2009-2010); the whale #9, female, was sighted in summer-winter-summer (2006-2007), and in the winter-summer (2011); and the whale #11, was sighted in summer-winter-summer (2007-2008), and in the summer-winter (2009-2010) (Table 3).

The whales #5, #6 and #12 were sighted the same day, February 24 2006, and whale # 20 was sighted two days later in Laguna San Ignacio. The whales #5 and #12 were in the same group and #6 in a different group, suggesting that these animals were traveling in association with each other (Table 3).

The six known females were sighted with calves in the winter in Mexican waters and in the next summer in their feeding grounds, three of them without calves (Table 3), suggesting that these females had either separated from their calves (e.g. weaned) or that their calves did not survive (e.g., due to predation).

The female #7 was observed with calf in March 11, 2009 in Laguna San Ignacio and 122 days later, on July 11, off the Kamchatka Peninsula where she stayed with her calf at least until September 2. The female #14 was observed with calf on February 17, 2011 in Laguna San Ignacio and 140 days later in Sakhalin Island.

The time between the last sighting in one season and the first one in the next season was $\bar{x}$=195.4 days (n=11, 141-255) during the summer-winter migration, and $\bar{x}$=165.6 days (n=13, 131-213) during the winter-summer migration. The shorter time between Laguna San Ignacio and Sakhalin was of the whale #13, of unknown sex, with 131 days followed by the whale #4, a male, with 139 days, and the whales #8, #11, and #14, mothers with calves, with 144, 143, and 140 days respectively (Table 3).Table 2. Sighting summary information for 13 gray whales matched between Sakhalin and Mexico. * = With calf.

	Russia-US		IBM		UABCS		Russia-US
#	**No.**	**Years**	**No.**	**Year(s)**	**No.**	**year(s)**	**Sex**
1[1]	20	97,02-04,07,09,11	80	06,07	06-0209-D-LSI	06	M
2[1]	52	98,99,00,01,02, 03,05,06,08,09,10,11	26	02,05,08	07-0328-I-LSI, 10-0639-D-LSI	07,10	M
3	27	95,97,98,99,00,01,02, 04,05,06,07,09,10,11	2	02,05	02-0336-D-LOL	02	M
4	91	00,05,07,08,09,11	137	07	11-0273-D-LSI	11	M
5	28	97,98,99,00,01,03,04, 05,06,07,09,11	59	05,07	06-0131-D-LSI	06	M
6	69	98,00,01,02,03,04, 08,09,11	113	04,05,07	06-0176-D-LSI	06	M
7[1]	42	97,98,99,00,03, 04,05,11	90	03,05,09*	09-0696-D-LSI-M	09*	F
8[1]	63	97,98*,00,01,02 05,07,08,10,11*	47	03,05,07	08-107-I-LSI-M	08*	F
9	103	01,02,04,05,11	119	05,06,07	07-0457-D-LSI, 11-0526-D-LSI-M	07,11*	F
10	29	97,98,00,01,02,03,04, 05,07,09,10,11	28	03,05	10-0739-D-LSI-M	10*	F
11	85	99,01,02,04,05,08*,09, 11	51	04,05,07	08-0051-D-LSI-M, 10-0396-D-LSI	08*,10	F
12	94	00,03,04,05,07,11	57	03,06,07,08	06-0132-D-LSI	06	U
13			166	09	09-0506-D-LSI	09	U
14	3	97,99,04,05,06,09	144	05,06,07,08,11*	11-0505-D-LSI-M	11*	F

[1]Reported in Weller *et al*. 2011, [2]Observed only off Kamchatka

Table 3. Gray whales sighted in consecutive seasons.

#	Sakhalin (Summer) RusUS	IBM	Mexico (Winter) UABCS	Sex	Summer	Days	Winter	Days	Summer
1	20	80	06-0209-D-LSI	M			26-Feb-2006	213	27-Sep-2006
2	52	26	07-0328-I-LSI, 10-0639-D-LSI	M	22-Aug-2006 07-Aug-2009	181 217	20-Feb-2007 13-Mar-2010	 177	 06-Sep-2010
3	27	2	02-0336-D-LOL	M	31-Jul-2001	217	06-Mar-2002	150	03-Aug-2002
4	91	137	11-0273-D-LSI	M			01-Mar-2011	139	18-Jul-2011
5	28	59	06-0131-D-LSI	M	07-Aug-2005	200	24-Feb-2006	179	22-Aug-2006
6	69	113	06-0176-D-LSI	M	23-Ags-2005	184	24-Feb-2006		
7	42	90	09-0696-D-LSI-M	F			11-Mar-2009*	122	11-Jul-2009*
8	63	47	08-107-I-LSI-M	F	09-Sep-2007°	201	29-Mar-2008*	144	20-Aug-2008°
9	103	119	07-0457-D-LSI, 11-0526-D-LSI-M	F	17-Oct-2006”	141	08-Mar-2007° 08-Mar-2011*	189 170	13-Sep-2007” 25-Aug-2011°
10	29	28	10-0739-D-LSI-M	F	07-Aug-2009°	219	14-Mar-2010* 29-Mar-2010*	176	06-Sep-2010°
11	85	51	08-0051-D-LSI-M, 10-0396-D-LSI	F	16-Sep-2007” 24-Jul-2009	163 255	26-Feb-2008* 06-Mar-2010*	143	19-Jul-2008*
12	94	57	06-0132-D-LSI	U	06-Sep-2005	171	24-Feb2006	203	16-sep-2006
13		166	09-0506-D-LSI	U			04-Mar-2009	131	113-Jul-2009
14	3	114	11-0505-D-LSI-M	F			17-Feb-2011*	140	07-Jul-2011*

*with calf
°without calf
“presence of calf unknown

DISCUSSION

The 14 individuals sighted in Mexican waters represent about 10% of the western gray whale population based on the population assessment of an estimate of 130 individuals (90% Bayesian CI = 120-142) (Cooke *et al.* 2008). If we combine these matches with the six matches found off the coast of Vancouver Island reported by Weller *et al.*, (2011), presumably during their migration from the breeding lagoons along the Mexican coast, and the two genetic matches noted by Lang *et al.*, (2011) with whales sampled in southern California, a total of 22 whales identified as part of the western gray whale population have migrated, at least in some years, to the eastern North Pacific during the winter breeding season.

The presence of three of these whales the same day in Laguna San Ignacio, two in the same group, indicate that these whales may travel in association or in groups, as Weller *et al.*, (2011) observed based on six matches off Vancouver Island, British Columbia, Canada. This also suggests that these whales may stay together in groups while on the breeding grounds.

The sex of the whales (six males, six females and two of unknown sex) indicates that both sexes, in approximately equal numbers, migrate to Mexican waters during the winter breeding season.

The sighting of females without their calves on the Russian feeding grounds suggests a high mortality of the calves, based on the small sample of four mothers with calf sighted in Laguna San Ignacio and the next summer off Sakhalin and one off Kamchatka (i.e., only a 50% survivorship). The long distance of their migratory destination compared to the Bering and Chukchi Seas could be an important factor in the survivorship of the calves. Alternatively, these females may have separated from their calves as the normal weaning process when the calves were of sufficient age to begin foraging for themselves.

The number of days between the last photograph of the season and the first one of the next season represents the maximum migration time and depends on the presence of the whale, the chance to find and photograph it, and the field work seasons of the different research teams. The shorter times observed between Laguna San Ignacio and Sakhalin, 131-143 days, could be close to the real migration times of these whales.

The matches made between whales sighted off Sakhalin and the Mexican Pacific are the first results of the multinational collaboration "PACIFIC WIDE STUDY ON POPULATION STRUCTURE AND MOVEMENT PATTERNS OF NORTH PACIFIC GRAY WHALES" initiated under the coordination and support of the International Whaling Commission last year. Additional comparisons and analyses of photographs from the Western and Eastern gray whales are ongoing and will include photographs from the IBM Sakhalin catalogue 2008-2011, IBM Kamchatka catalogue, and from Laguna San Ignacio and Bahia Magdalena winter aggregation and breeding areas, obtained during the winter 2012.

Acknowledgements

We wish to thank our field researchers and colleagues that assisted with the documentation of the gray whales in Laguna San Ignacio and Laguna Ojo de Liebre. We also thank The Ocean Foundation, and the World Wildlife Fund-Mexico for their support of the field work and analysis of our results. This research was conducted as part of the Laguna San Ignacio Ecosystem Science Program (LSIESP) under special scientific research permits No.SGPA/DGVS/11560/10 and SGPA/DGVS/00640/12from the Subsecretaría de Gestión Para La Protección Ambiental, Dirección General de Vida Silvestre, de Mexico.

References.

Cooke JG, Weller DW, Bradford AL, Burdin AM, Brownell RL, Jr. (2008) Population assessment of western gray whales in 2008. Paper SC/60/BRG11 presented to the International Whaling Commission Scientific Committee. [Available from http://www.iwcoffice.org/]

IWC (2011) Report of the 2011 IWC Scientific Committee. Tromso, Norway. [Available from http://www.iwcoffice.org/]

Lang AR, Weller DW, LeDuc R, Burdin AM, Pease VL, Litovka D, Burkanov V, Brownell, RL, Jr. (2011) Genetic analysis of stock structure and movements of gray whales in the eastern and western North Pacific. Paper SC/63/BRG10 presented to the International Whaling Commission Scientific Committee. [Available from http://www.iwcoffice.org/]

Weller, DW, Klimek, A., Bradford, A.L., Calambokidis, J., Lang, A.R., Gisborne, B., Burdin A.M, Szaniszlo, W., and Brownell RL, Jr. (2011) Movements of western gray whales from the Okhotsk Sea to the eastern North Pacific.

Paper SC/63/BRG6. 5pp Submitted to the International Whaling Commission Scientific Committee. [Available from http://www.iwcoffice.org/]

CALIFORNIA GRAY WHALE COALITION
PROTECTING THE MOST ANCIENT BALEEN WHALE ALIVE TODAY

P. O. Box 50939 Palo Alto, CA 94303 Ph: 650 322 4729
Email: info@californiagraywhalecoalition.org • www.californiagraywhalecoalition.org

11/10/2012

SUBMISSION TO NATIONAL MARINE FISHERIES SERVICE ON P G & E HESS

Comments in relation to:

Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California, November to December, 2012

-A Notice by the National Oceanic and Atmospheric Administration on 09/19/2012

The California Gray Whale Coalition, representing more than 130 organisations along the west coast of North America, including many whale watching companies and environmental organisations, strongly objects to the proposed High Energy Project on the following grounds:-

MMPA definition of "Harassment"

- Level A Harassment- has the potential to injure a marine mammal or marine mammal stock in the wild.
- Level B Harassment- has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioural patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding or sheltering.

ESA definition of Harm

- Any act which actually kills or injures.
- * Includes significant habitat modification or degradation which kills or injures by significantly impairing essential behavioural patterns, including breeding, migrating, feeding.

The Coalition believes the proposed study constitutes Level A, Level B Harassment and Harm as defined by the MMPA and ESA.

LEVEL B TAKE VERSUS LEVEL A

Given the fact that Temporary Threshold Shift (TTS) and Permanent Threshold Shifts (PTS) can ONLY be determined by necropsies, it cannot be scientifically acceptable to claim that blasting these levels of noise at migrating Gray whales will not cause damage.

The Coalition has not been able to determine any post project surveys for any species. Nor is there any indication of how post project surveys (assuming any) would be undertaken; the parameters of such surveys; indications of problems, methodology, mortality, stranding, calf mortality, reproduction failure, stress and immune disorders; disruption of communication etc. etc. Without post project surveys which are capable of identifying mortality or injuries, impairment of essential behavioural patterns, the determination of Level B Harassment is optimistic.

> Noise impacts on Gray whales have been well researched and there is evidence that the whales are sensitive to low, medium and high frequency. As pregnant gray whales lead the migration procession and are well documented as present in the area during November and December, the ramifications of allowing this HESS to take place at this time are likely to be disastrous.

Calves born along the migration route face significant threats as detailed by Dr. Wayne Perryman, [1]
SWFSC, La Jolla.

"*If a calf is born along the migration route, it will be required to migrate instead ofjust hanging around. This would cause it to burn more energy. Calves are born skinny with little or no insulative blubber layer so they will burn up some energy just keeping warm. The water in the lagoons is not only warm, but the salinity is very high. Calves can float easily to the surface in the lagoon's high-density water, while calves born in the lower salinity waters along the California coast may have to swim to the surface, and the higher waves can make them more vulnerable to drowning. Probably the most important disadvantage of being born along the migration route is that killer whales can find the calves. There are normally no killer whales in the lagoons so it is a safer place if you are a calf."*

A report on Climate Change Impacts[2] (2010) concurs:-

Warming sea temperature likely will result in a shift north of breeding areas. Gray whales (Eschrichtius robustus) for example, appear to be giving birth as far north as Monterey Bay expanding north from lagoons of Baja, Mexico. Giving birth outside the sheltered Baja calving lagoons presents greater risk of storm stress to newborn calves as well as increased risk of predation by killer whales and large sharks.

> Whilst last season's cow calf count was demonstrably higher than previous four seasons, one good season cannot possibly be described as a "recovery". With massive changes taking place in the Gray Whales primary feeding grounds and habitat (Arctic and sub-Arctic) combined with whales migrating further north in search of prey, their status can only be described as vulnerable.

---

[1] Dr Wayne Perryman, interview Journey North.
[2] Report of Joint Working Group of the Gulf of the Farallones and Cordell Bank National Marine Sanctuary Advisory Councils Climate Change Impacts 2010.

The Precautionary Principle must be paramount in any management decisions.

WESTERN PACIFIC GRAY WHALE.

- The NMFS Federal Register Notice and all previous studies have completely failed to take into account the presence of the highly endangered Western Pacific Gray Whales in the area. The number of these whales appears to be increasing (paper attached) and it is not possible to predict when and where they may be sighted.
- Because of the difficulty of identifying Western and Eastern North Pacific Gray Whales, and the fact that the studies will be conducted 24 hours a day, 7 days a week, it will be impossible to detect Western Pacific Gray whales. at night.
- The highly endangered status of the Western Pacific Gray Whale ensures there is no PBR level.

EASTERN NORTH PACIFIC GRAY WHALE.

The disregard for the ENP Gray Whale is of major concern to the Coalition. A number of important points need to be raised.

No recent population assessment of the ENP Gray whale is currently available. According to the Draft SAR 2012, *" the most recent estimate of abundance is from 2006/2007 southbound survey or l9,126 whales. The most recent southbound counts were made during 2007/2008, 2009/2010 and 2010/2011 surveys from which abundance estimates are not yet available."*

This is an outrageous and unprecedented situation. It is now 6 years since NMFS has made available a current population figure. There is no precedent in the last 23 years of population estimates that a current figure has not been made available for six years. In spite of the lack of any current estimate, the following figures are quoted in various documents.

Population numbers

1. **19,126 Gray whales** According to the Federal Register Notice relevant to HESS.

2. **17,752 gray whales -** Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to Shallow Hazards Survey in the Chukchi Sea, Alaska

A Notice by the National Oceanic and Atmospheric Administration on 08/03/2011

3. Indeterminate number. **Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to Marine Seismic Survey in the Beaufort Sea, Alaska -**

A Notice by the National Oceanic and Atmospheric Administration on 07/06/2012

4. 19,126 Gray whales
Takes of Marine Mammals Incidental to Specified Activities: taking Marine Mammals Incidental to a Marine Geophysical Survey in the Arctic Ocean, September- October 2011.
A Notice by the National Oceanic and Atmospheric Administration on 07/14/2011.

5. 18,017 Gray whales
Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to an Exploration Drilling Program Near Camden Bay, Beaufort Sea, AK;

A Notice by the National Oceanic and Atmospheric Administration on 11/07/2011

6. 18,017 Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to an Exploration Drilling Program in the Chukchi Sea, Alaska

A Notice by the National Oceanic and Atmospheric Administration on 11/09/2011

Interestingly, the NOAA Office of Protected Resources Gray whale page cites the following under population:-

The most recent abundance estimates are based on counts made during the 1997/98, 2000/01, and 2001/02 southbound migrations, and range from about 18,000-30,000 animals.

The Coalition believes it is abundantly obvious that NMFS plucks figures out of the air to suit particular projects and that until such time as a current population estimate is available, no project should be permitted.

Potential Biological Removal (PBR)

The Potential Biological Removal (PBR) level is the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.

The number of Gray Whales which can be removed from the stock is a key issue and the PBR set by NMFS has been a matter of controversy for many years given the changes in methodology; changes in population assessments; lack of current data and research into the implications of setting high PBR at a time when the population suffered a major population crash in 1999,2000..

Inexplicably, NMFS has set the PBR level in 2012, according to the Draft SAR 2012, at 558 animals based on a minimum population of l8,017. This is a massive increase from 360 animals in the previous Draft SAR (2010) when the stock, according to the report was at exactly the same number, that is a minimum population of 18,017.

There is no explanation as to why an extra 198 animals can be taken or why NMFS continues to use a six year old population estimate as the basis for the calculation.

The Coalition believes that there is considerable potential for Level A Harassment and that Level B take as outlined in the PG& E HESS may well translate into mortality. As an exercise, the Coalition has combined all known takes (A and B) demonstrating the PBR of 558 animals is entirely reachable.

Projected take – PG & E	97 whales	LEVEL B
IWC quota for Chukotka	140	LEVEL A
Beaufort Sea Take	3	LEVEL B
Chukchi Take (2)	46	LEVEL B
Arctic Ocean Take (3)	71	LEVEL B
Chukchi Take (4)	30	LEVEL B
Beaufort Sea Take (5)	30	LEVEL B
Chukchi Take (6)	46	LEVEL B
TOTAL	463 WHALES.	

It should be noted that figures in the Draft SAR for 2012 are not current for incidental mortality due to commercial fisheries, human caused deaths and serious injuries from fishery related sources (2006-2010), nor are stranding and entanglements (2005-2009)and nor the summary of Gray whale serious injuries and deaths attributed to vessel strikes for the period 2006-2010.

However, according to the Draft SAR 2012, based on 2006-2010 data, the estimated annual level of human caused mortality and serious injury and ship strikes total 128 whales per year.

THUS MAKING A TOTAL OF 591 – EXCEEDING THE PBR.

It must be stressed that the figures given can only be described as " rubbery" as without current data and current population estimates, not only has NMFS ignored is statutory responsibilities in monitoring the ENP gray whale population but the Agency cannot provide accurate and current statistics of human caused mortality.

It must be further stressed that the Coalition has combined Level A and Level B figures as an example of inappropriate management. The PBR level does not specify how many Level B harassments are acceptable nor is there any protocol which would determine the fate of animals exposed to Level B harassment. A significant risk factor is ignored in

PBR level calculations.

Further, at the Scientific Workshop which the Coalition ran over two days in late March, 2012, Dr Lance Barrett-Lennard and Craig Matkin, transient orca experts, gave evidence that the predation on Gray whale calves and juveniles fluctuates between 8-60% annually depending on the numbers of calves.

This predation rate is not taken into account in any PBR. The failure to include predation was a key criticism of the workshop participants along with the failure of NMFS to provide current population assessments.

Given the failures outlined above, there can be no scientifically acceptable figure which demonstrates an optimum sustainable population.

To allow a Level B take of 97 animals in a scenario with such paucity of adequate and current scientific information is simply unacceptable. Given that the timing of the study co-incides with the lead migration of heavily pregnant females and newborn young, the Coalition considers that a Level A take is more appropriate given the risks involved in exposing these animals to high frequency sonar.

PACIFIC FEEDING AGGREGATION.

Again, the documents fail to consider the Pacific Feeding Aggregation and the potential for some of these animals to be in the study area in November and December.

According to the Draft SAR 2012, " *satellite tagging studies between 3 September and 4 December 2009 off Oregon and California provide movement data for whales considered to be part of the PCFG (Mate et al 2010). Duration of tag attachment differed between individuals, with some whales remaining in relatively small areas within the larger PCFG seasonal range and others traveling more widely. All six individuals whose tags continued to transmit through the southbound migration utilized the wintering area within and adjacent to Laguna Ojo de Liebre.* "

The importance and vulnerability of this feeding aggregation is highlighted in the following excerpt:-

"Whales that utilize the northern feeding grounds migrate through the areas occupied by the southern feeding group, suggesting that whales from both known feeding grounds may migrate together the remainder of the way to the winter calving grounds (Darling 1984). The peak time of migrants passing through the southern feeding area is December (Darling 1984). Thus, the timing of fertilization coincides with when whales from different feeding grounds become intermingled during their southern migration. This pattern indicates the strong potential for interbreeding regardless of any substructuring that may exist during the summer, or on the winter calving grounds. Despite the presence of nuclear gene flow between whales from the southern feeding group and the rest of the population, this group still represents a separate management unit that

warrants separate consideration with respect to the proposed resumption of traditional whaling. The presence of long-term site fidelity to this area, that is passed on from mothers to offspring, indicates that these whales represent a seasonal subpopulation. Thus, detrimental impacts (i.e. "takes") to these whales will not have a "random" impact on the population at large, but will instead primarily impact these matrilines specifically. As a result, the resulting effect on this local subpopulation could be far greater than would be expected under the assumption of a single, unstructured population. Potential impacts could include the loss of knowledge of these feeding areas from this population, and localized extirpation. For example, if the whales that currently show this site fidelity are removed, then this information will be lost, and thus these whales will not likely be replaced by others from the larger population, resulting in localized extirpation. Indeed, the recognition of such seasonal subpopulations as separate management units is recommended, and common, for baleen whales (e.g. Dizon and Perrin, 1997). "[3]

ANNUAL MIGRATION CONFLICTS WITH STUDY DATES.

The Coalition submits data from the American Cetacean Society which demonstrates that Gray whales are in the project area in December. The migration is led by heavily pregnant gray whales with many calves being born offshore according to NMFS.

As well, the Coalition has canvassed whale watching companies who are members, up and down the coast and we can provide statutory declarations, if necessary, which demonstrate that Gray whales are often seen in the area as early as October.

NOISE ISSUES.

There are no comments about integrating all the exposures from 2 x 9 seismic airgun arrays, four vessels, multi-beam echosounder and sub-bottom profiler, and noise from aerial surveys. Thus the cumulative impact of the noise stressors has been ignored. Other threats are also important in evaluating the load.

"The following threats will almost certainly contribute in one way or another to a reduction in the condition of individuals (i.e., an increase in the "allostatic load"), which might, among other things, make them more susceptible to other potential stressors, including noise. As mentioned above, a reduction in the overall condition can also influence the psychological outlook of an animal .Although acting primarily on individuals, the impacts of these stressors may filter up to the population level if they affect an individual's survival or fecundity. These threats include:
•climate change and other ecosystem-wide change;

---

[3] 1 **Substructuring of mitochondrial, but not nuclear, markers in the** 2 **"southern feeding group" of eastern North Pacific gray whales**
3 4 ANNA M. D'INTINO1, JAMES D. DARLING2, JORGE URBÁN-RAMIREZ3, AND TIMOTHY R. FRASIER*1

• habitat loss or degradation through coastal and offshore development, fishery activity (including due to a reduction in available prey), inland development (that results in material washing downriver either immediately or over an extended period as a consequence of a change in land-use, such as clearing forests), etc.;
• disease;
•toxic algal blooms ; and
•contaminants (especially adrenocorticotoxic contaminants [4]"

GEOACOUSTIC PARAMETERS.

These parameters are constantly changing. Modeling is only capable of limited understanding of these changes . Different tides, seawater temperature, seabed alterations, weather and other factors all have the capacity to bring about major changes from day to day.

Thermoclines and ducting impact the geoacoustic parameters allowing noise to travel much further than calculated by modeling.

The received levels of noise impacting cetacea must be taken into account. Given the sensitivity of Gray whales and other mysticetes whales to noise, the current analysis is deficient and fails to take into account major issues relative to underwater noise.

> *Presently, the vocalization source level estimates reported in the review literature on mysticetes cover a 60 dB range between about 130 and 190 dB re 1uPa (see e.g., Wartzok & Ketten, 1999);*
>
> *A variety of different behavioral responses including changes in acoustic behavior have been observed from mysticetes in response to the presence of specific sounds, or to stimuli (such as sea vessels) paired with specific sounds. These include changes in movement patterns and diving behavior; approach or avoidance responses; alterations in respiratory patterns; changes in aerial behaviors such as breeching; and modifications of acoustic behavior including call rate, structure, and duration (see Richardson et al. 1995; Miller et al., 2000). Historically, the behavior of mysticetes has been difficult to observe, and the tools for measuring responses have been somewhat crude, including theodolite tracks measured from shore stations and visual and acoustic observations made by shipboard observers. As a result, while significant behavioral changes to sound sources have been detected, it is nearly certain that more subtle responses to less salient stimuli have been overlooked (see discussion in Tyack et al., 2003/4).*

---

[4] *International Journal of Comparative Psychology*, 2007, **20**, 274-316. Copyright 2007 by the International Society for Comparative Psychology
Do Marine Mammals Experience Stress Related to Anthropogenic Noise?

While gross measures of behavioral change may be appropriate for identifying strong, suprathreshold responses, inferences about hearing capabilities are improved by assessing the lower limits of responsivity to auditory cues. Despite the constraints imposed by limited response detection capabilities, the reliable responses that have been measured from mysticetes to date have served to identify sound types and levels that are convincingly detectable by individuals of different species. For example, such studies have shown that some mysticetes respond to sounds as low in frequency as 20 Hz, as high in frequency as 28 kHz, and as low in level as ~84 dB re 1 μPa (or ~6 dB above ambient noise) (see reviews in Richardson, 1995; see also Lucifredi & Stein,

Two studies in particular have intentionally explored features of auditory function in mysticetes. In a pilot study, Dahlheim and Ljungblad (1990) attempted to determine the feasibility of conducting hearing assessments on gray whales swimming through a channel in Laguna San Ignacio, in Baja California. The investigators placed a bottom mounted transducer in a region of the channel with known physical characteristics of the water column and bottom topography and calibrated the tonal stimuli to be used in the study at various positions surrounding the sound source. As whales moved through the study area, a 1-second signal of pre-determined frequency and level was played from the transducer. Control exposures, in which no sound was presented to focal individuals, were also conducted. Whale behavior was measured from two independent observation stations before, during, and immediately after each exposure. Sound frequencies tested ranged from 200 to 2500 Hz, and startle responses were documented to stimuli between 100 and 1500 Hz at received exposure levels of 100 to 135 dB re 1 μPa.

Using a different approach, Frankel, Mobley and Herman (1995) derived response thresholds for playbacks of social and synthetic sounds to humpback whales off the coast of Hawaii. The sound levels received by individual whales during the playbacks were modeled and then verified with empirical transmission loss measurements. The investigators reported behavioral responses measured from shore stations to social sounds as low as 102 dB re 1 μPa and to synthetic sounds as low as 106 dB re 1 μPa. While the relatively overt behavioral responses measured in this study likely underestimate absolute hearing sensitivity to the playback stimuli, this titration of stimulus levels moves closer to revealing true sound detection capabilities in whales.

It is worth pointing out that for the purposes of hearing assessment—where response magnitude is likely to decline with stimulus saliency—the observation of subtle, biologically insignificant but reliable responses to low amplitude sounds will be critical in closing the gap between estimation of response thresholds and absolute auditory thresholds.

Changes in acoustic behavior as a function of different noise conditions may potentially include differences in the level, rate, duration, and frequency

bandwidth of vocalizations; these differences can in turn be related to auditory phenomena such as detection, masking, and hearing loss.

Aspects of motivation also come into play when interpreting behavioral responses to sound, for example, it may be quite difficult to elicit a response from whales that are engaged in
active feeding, social interactions, or mating, but much easier to elicit responses from individual whales that are traveling or resting quietly (see Richardson, 1995).[5]

EXCERPTS

Coastal Commission Comments on the Effects of Anthropogenic Sound on Marine Mammals Statement for The Report of the Advisory Committee on Acoustic Impacts on Marine Mammals to the Marine Mammal Commission Submitted by: Sara Wan, California Coastal Commission
on behalf of: Meg Caldwell, Chair, California Coastal Commission
Submission Date: December 13, 2005

2) there have been no studies that have attempted to study population declines due to noise;
3) if we were able to detect a population decline, it would be difficult if not impossible to tie it to noise;

Eighty-three different species of cetaceans are currently recognized, and audiograms have been developed for only 11 species, all of which are odontocetes.

- The hearing of mysticete whales remains unmeasured.
- Uncertainty regarding the specific uses of sound by marine mammals (e.g., extent, context) makes it difficult to detect or interpret changes in behaviors associated with sound.
- We know relatively little about the extent of marine mammals' ' use of sound from natural sources (for navigation, prey detection, predator avoidance, or other uses).
- There is uncertainty about how marine mammals use sound to communicate or carry out other functions.
- The ranges and circumstances of effective communication using sound are also unclear.
- There is limited information available on what constitutes normal behavior for many species.

---

5 Assessing the hearing capabilities of mysticete whales
A proposed research strategy for the Joint Industry Programme on Sound and Marine Life. 2007 Colleen Reichmuth, UCSC.

- There is a lack of baseline behavioral data making it difficult to assess the impact of sound or determine what would constitute a biologically significant disturbance.

- There is uncertainty about whether an animal hears the same types of sounds that it produces, and therefore whether it is appropriate to estimate an animal' 's audiogram by examining its sound production.
- There is uncertainty about whether or not sounds to which animals are relatively insensitive are still important to their survival.
- There is uncertainty about the pathways by which sound travels to the inner ear and about other mechanisms for hearing in marine mammals.
- There is uncertainty about the onset of auditory trauma in marine mammals, including which types and levels of sound exposures will induce trauma in which species
- . There are limited experimental data on TTS (temporary threshold shift) in marine mammals, and no experimental data on PTS (permanent threshold shift, i.e., deafness).
- It is uncertain whether increased sound levels in the oceans could cause auditory
- developmental problems for young marine mammals.
- We do not know whether marine mammals have natural mechanisms to protect their hearing. If they do have protective mechanisms, they may not work in the same way as in the ears of terrestrial mammals. If marine mammals do have protective mechanisms, we do not know whether or how they might fatigue.
- There is uncertainty about whether the auditory systems of mysticetes may be more likely than those of odontocetes to be affected by low- to mid-frequency sounds because mysticetes' ' vocalizations consist of these same frequencies.
- While masking is known to be a common, naturally occurring phenomenon, there is uncertainty about the specific conditions under which, and the extent to which, it occurs in marine mammals, and when it is significant.
- The full range of options available to marine mammals to overcome masking is not known.
- There is uncertainty about the potential of general, non-directional ambient noise to cause masking, which results from a lack of information about ambient noise levels
- Uncertainties exist about baseline feeding rates and hunting success, mate-searching behavior, and predator avoidance affecting scientists' ' understanding of whether masking is likely to adversely affect the survival or reproductive success of an individual or population.
- Direct effects of masking are difficult to demonstrate in the field.
- The prevalence of non-auditory physiological sound effects (e.g., stress, neurosensory effects, effects on balance, tissue damage from acoustic resonance, gas bubble growth in tissues and blood and blast-trauma injury) in marine mammals and the relative vulnerability of different species to such effects are uncertain.

MONITORING

These recommendations, made by two of the most recognised experts in the US, have not been addressed by NMFS. The Coalition believes the following statements are critical in assessing the proposed study.

"The monitoring of anthropogenic sound and its effects on marine mammals is achieved through the following procedures**.. (c) Postactivity surveys of marine mammals that were exposed to, and thus may have been affected by, the activity are conducted** (Coalition emphasis) . The nature of such surveys (e.g., aerial surveys, shore-based visual surveys, passive acoustic surveys) can vary on the basis of the activity and environmental conditions.[6]

Science foundation

In order to create an acoustic-habitat framework, science foundations must (a) summarize natural and anthropogenic sound sources by region and period; (b) map the sound fields generated by each source; (c) merge the sound field maps to depict the overall acoustic habitat and highlight areas in which cumulative effects are likely to occur; (d) list marine-mammal species and all proposed offshore activities by region and period; and (e) summarize the behavioral ecology for marine-mammal species by region and season and map distribution, relative abundance, and ecologically important areas (e.g., those used for feeding, breeding and migration).

Acoustic-habitat framework

The acoustic-habitat framework must (a) overlay acoustic-habitat maps with maps of marine-mammal distribution patterns, relative abundance, and ecological importance and (b) identify areas or periods of concern and data gaps, including limitations on the understanding of sound sources and propagation, as well as the behavioral ecology of potentially affected marine mammals.[7]

---

[6] A New Framework for Assessing the Effects of Anthropogenic Sound on Marine Mammals in a Rapidly Changing Arctic
SUE E. MOORE, RANDALL R. REEVES, BRANDON L. SOUTHALL, TIMOTHY J. RAGEN, ROBERT S. SUYDAM, AND CHRISTOPHER W. CLARK

[7] ibid

STRESS.

The following paper is attached as evidence of stress which has not been taken into account :-

Considerations of the Effects of Noise on Marine Mammals and other Animals
Andrew J. Wright and Lauren Highfill, *Guest Editors*
2007, Volume 20, Numbers 2-3 International Journal of Comparative Psychology

CONCLUSION

The Coalition concludes its submission by highlighting the major points of objection.

- No current population estimate for ENP Gray whales. The latest published estimate is 2006/07.
- No acknowledgement of the likely presence of Western Pacific Gray Whales
- No acknowledgement of the likely presence of Pacific Feeding Aggregation whales.
- Concern that November and December are critical months for the migration of heavily pregnant Gray whales and newborn calves
- Sensitivity of Gray whales to low mid and hi frequency sonar
- Lack of audiograms for most species which will be impacted by sonar
- Inappropriate designation of Level B Harassment
- PBR level is invalid and if the " take" becomes a Level A take, the number of whales taken could be of concern.
- Lack of any proper post-survey studies and methodology.
- Cumulative impact of seismic airguns, multibeam echo sounder, sub-bottom profiler, and noise from aerial surveys

The Coalition submits the PG&E HESS should not be allowed to proceed.

Yours truly,

Sue Arnold *Hunter Kilpatrick*

Sue Arnold
CEO

Hunter Kilpatrick
Central Coast Director

GRAY WHALE CENSUS AND BEHAVIOR STUDY
AMERICAN CETACEAN SOCIETY, LOS ANGELES CHAPTER
PT. VICENTE 1990-2011

DECEMBER 2011

Day	Observ Period	Total Hours	SOUTHBOUND Daily Sitngs	Daily Whales	Daily C/C
1	0545-1700	11.25	0	0	0
2	0600-1700	11.00	0	0	0
3	0545-1700	11.25	1	1	0
4	0600-1700	11.00	1	1	0
5	0600-1700	11.00	0	0	0
6	0545-1700	11.25	0	0	0
7	0600-1700	11.00	0	0	0
8	0545-1700	11.25	0	0	0
9	0600-1700	11.00	0	0	0
10	0515-1700	11.75	3	3	0
11	0600-1700	11.00	1	3	0
12	0600-1700	11.00	2	2	0
13	0545-1700	11.25	2	2	0
14	0600-1700	11.00	4	7	0
15	0530-1700	11.50	1	2	0
16	0600-1700	11.00	4	5	0
17	0545-1700	11.25	2	5	0
18	0600-1700	11.00	2	2	0
19	0615-1700	10.75	4	4	0
20	0530-1715	11.75	6	9	0
21	0600-1700	11.00	8	10	0
22	0530-1700	11.50	12	18	0
23	0600-1700	11.00	5	8	0
24	0530-1700	11.50	11	21	0
25	0545-1730	11.75	13	17	0
26	0600-1715	11.25	15	27	2
27	0530-1700	11.50	11	16	0
28	0600-1715	11.25	6	6	0
29	0600-1615	10.25	13	17	0
30	0615-1615	10.00	5	5	0
31	0530-1615	10.75	0	0	0
				191	

345.00 TOTAL HRS FOR MONTH

DECEMBER 2010

Day	Observ Period	Total Hours	SOUTHBOUND Daily Sitngs	Daily Whales	Daily C/C
1	0600-1700	11.00	0	0	0
2	0530-1700	11.50	0	0	0
3	0600-1700	11.00	0	0	0
4	0600-1700	11.00	0	0	0
5	0600-1700	11.00	0	0	0
6	0600-1700	11.00	0	0	0
7	0600-1700	11.00	0	0	0
8	0600-1700	11.00	0	0	0
9	0600-1700	11.00	0	0	0
10	0600-1700	11.00	0	0	0
11	0600-1700	11.00	0	0	0
12	0600-1700	11.00	0	0	0
13	0600-1700	11.00	1	1	0
14	0600-1700	11.00	0	0	0
15	0630-1700	10.50	0	0	0
16	0600-1700	11.00	0	0	0
17	0600-1700	11.00	0	0	0

18	0600-1700	11.00	2	3	0
19	0615-1700	10.75	1	1	0
20	0600-1700	11.00	0	0	0
21	0600-1700	11.00	4	7	0
22	0830-1700	8.50	2	3	0
23	0600-1700	11.00	1	1	0
24	0600-1700	11.00	3	5	0
25	0600-1700	11.00	2	4	0
26	0600-1700	11.00	1	1	0
27	0600-1700	11.00	4	6	0
28	0600-1700	11.00	0	0	0
29	0630-1700	10.50	3	4	0
30	0600-1700	11.00	2	2	0
31	0600-1700	11.00	0	0	0
				38	

337.75 TOTAL HRS FOR MONTH

DECEMBER 2009 SOUTHBOUND

Day	Observ Period	Total Hours	Daily Sitngs	Daily Whales	Daily C/C
1	0545-1700	11.25	1	2	0
2	0600-1700	11.00	0	0	0
3	0545-1700	11.25	0	0	0
4	0545-1700	11.25	0	0	0
5	0545-1700	11.25	0	0	0
6	0600-1700	11.00	0	0	0
7	0600-1700	11.00	1	1	0
8	0530-1700	11.50	0	0	0
9	0600-1700	11.00	0	0	0
10	0545-1700	11.25	0	0	0
11	0600-1700	11.00	0	0	0
12	0545-1700	11.25	0	0	0
13	0615-1700	10.75	0	0	0
14	0600-1700	11.00	0	0	0
15	0545-1700	11.25	0	0	0
16	0600-1700	11.00	1	2	0
17	0545-1700	11.25	2	2	0
18	0600-1700	11.00	0	0	0
19	0545-1700	11.00	0	0	0
20	0615-1700	10.75	0	0	0
21	0600-1700	11.00	1	1	0
22	0600-1645	10.75	0	0	0
23	0600-1700	11.00	1	1	0
24	0600-1700	11.00	1	1	0
25	0600-1700	11.00	4	4	0
26	0545-1700	11.25	1	2	0
27	0615-1730	11.25	1	1	0
28	0600-1700	11.00	1	2	0
29	0600-1700	11.00	1	2	0
30	0600-1700	11.00	1	1	0
31	0600-1700	11.00	0	0	0
				22	

343.25 TOTAL HRS FOR MONTH

DECEMBER 2008 SOUTHBOUND

Day	Observ Period	Total Hours	Daily Sitngs	Daily Whales	Daily C/C
1	0600-1700	11.00	0	0	0

2	0600-1700	11.00	0	0	0
3	0600-1700	11.00	1	3	0
4	0600-1700	11.00	0	0	0
5	0600-1700	11.00	0	0	0
6	0545-1700	11.25	0	0	0
7	0600-1700	11.00	3	6	0
8	0600-1700	11.00	1	2	0
9	0545-1700	11.25	1	3	0
10	0600-1700	11.00	2	3	0
11	0600-1700	11.00	0	0	0
12	0600-1700	11.00	1	1	0
13	0545-1715	11.50	2	4	0
14	0600-1700	11.00	1	1	0
15	0600-1700	11.00	1	3	0
16	0545-1700	11.25	2	3	0
17	0600-1700	11.00	1	2	0
18	0600-1700	11.00	1	1	0
19	0600-1700	11.00	1	3	0
20	0545-1700	11.25	3	4	0
21	0545-1700	11.25	3	7	0
22	0600-1700	11.00	0	0	0
23	0600-1700	11.00	1	2	0
24	0600-1700	11.00	1	1	0
25	0600-1700	11.00	1	1	0
26	0600-1700	11.00	3	3	0
27	0600-1700	11.00	2	4	1
28	0600-1700	11.00	0	0	0
29	0600-1700	11.00	0	0	0
30	0600-1700	11.00	3	3	0
31	0600-1700	11.00	2	2	0
		342.75	TOTAL HRS FOR MONTH	62	

DECEMBER 2007 SOUTHBOUND

Day	Observ Period	Total Hours	Daily Sitngs	Daily Whales	Daily C/C
1	0530-1700	11.50	0	0	0
2	0545-1700	11.25	0	0	0
3	0545-1700	11.25	0	0	0
4	0545-1700	11.25	0	0	0
5	0600-1700	11.00	0	0	0
6	0600-1700	11.00	0	0	0
7	0600-1700	11.00	0	0	0
8	0530-1700	11.50	2	13	0
9	0515-1700	11.75	0	0	0
10	0545-1700	11.25	0	0	0
11	0545-1700	11.25	1	1	0
12	0600-1700	11.00	1	1	0
13	0545-1700	11.25	0	0	0
14	0545-1700	11.25	0	0	0
15	0530-1700	11.50	0	0	0
16	0530-1700	11.50	1	1	0
17	0545-1700	11.25	1	1	0
18	0600-1600	10.00	1	1	0
19	0600-1700	11.00	0	0	0
20	0600-1645	10.75	0	0	0
21	0600-1715	11.25	1	2	0
22	0530-1700	11.50	0	0	0
23	0530-1700	11.50	1	1	0
24	0530-1700	11.50	1	1	0
25	0545-1700	11.25	3	7	0
26	0600-1700	11.00	1	1	0
27	0600-1715	11.25	1	1	0

28	0600-1700	11.00	0	0	0
29	0600-1700	11.00	1	1	0
30	0530-1700	11.50	1	1	0
31	0545-1715	11.50	1	1	0
				34	
		347.75	TOTAL HRS FOR MONTH		

CALIFORNIA GRAY WHALE COALITION
PROTECTING THE MOST ANCIENT BALEEN WHALE ALIVE TODAY

P. O. Box 50939 Palo Alto, CA 94303 Ph: 650 322 4729
Email: info@californiagraywhalecoalition.org • www.californiagraywhalecoalition.org

P. Michael Payne 11/10/2012
Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, Md. 20910

Mr. Payne,

Enclosed you will find our submission along with documents supporting photographic identification of Western Gray's, the ACS/LA census data for December 2007-2011 and an article from the International Society for Comparative Psychology (emailed only – it's a big one) on the effects of noise on marine mammals and other animal.

Please feel free to contact me if you would like any information clarified or would like more data on any issue of this.

Sincerely

Hunter Kilpatrick

Hunter Kilpatrick
Central Coast Director - CCWG
2647 Greenwood Ave. #C
Morro Bay, Ca. 93442
(805) 772-7501
morrobayhunter@yahoo.com

ITP Goldstein <itp.goldstein@noaa.gov>

Submission to IHA for PGE HESS

hunter kilpatrick <defanhk@sbcglobal.net> Fri, Oct 12, 2012 at 2:02 AM
Reply-To: hunter kilpatrick <defanhk@sbcglobal.net>
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>

Please see my attached submission and supporting documents requesting the denial of the current IHA request from PGE for the proposed HESS in California.
Thank you very much
Hunter Kilpatrick
Marine Naturalist
805-772-7501

3 attachments

Pt. Vicente GW Census Data (Dec) 2007-2011.pdf
136K

my submission to NMFS.pdf
243K

WESTERN GRAY WHALE MIGRATION.pdf
172K

ITP Goldstein <itp.goldstein@noaa.gov>

forward from Lindy Weilgart Ph D

hunter kilpatrick <defanhk@sbcglobal.net> Wed, Sep 19, 2012 at 2:29 AM
Reply-To: hunter kilpatrick <defanhk@sbcglobal.net>
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>

Lindy Weilgart PhD has asked me to forward the attached report to you. It was originally written to the State Lands Commission prior to their hearing on the proposed HESS off California.
Sincerely
Hunter Kilpatrick

Letter from Lindy to California State Lands Commission.pdf
204K

PHOTOGRAPHIC COMPARISON OF THE WESTERN AND MEXICAN GRAY WHALE CATALOGUES: 2012.

J. Urbán R.[1], D. Weller[2], O. Tyurneva[3], S. Swartz[4], A. Bradford[5], Y. Yakovlev[3], O. Sychenko[6], H. Rosales N[1]., S. Martínez A[1]., A. Burdin[6] and A. Gómez-Gallardo U.[1]

[1] *Programa de Investigación de Mamíferos Marinos. Universidad Autónoma de Baja California Sur, La Paz, B.C.S., Mexico*

[2] *Protected Resources Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 3333 North Torrey Pines Court, La Jolla, CA, 92037-1022 USA*

[3] *A.V. Zhirmunsky Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Sciences, Vladivostok, 690041, Russia.*

[4] *Laguna San Ignacio Ecosystem Science Program, Darnestown, MD, USA*

[5] *Protected Species Division, Pacific Islands Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Honolulu, HI, USA*

[6] *Kamchatka Branch of Pacific Institute of Geography, Far East Branch - Russian Academy of Sciences, Petropavlovsk, Kamchatka, Russia*

ABSTRACT

Photographs of 217 identified gray whales obtained from the Sakhalin Island, Russia feeding grounds were compared with 6,546 photo-identified individuals from the Baja California Peninsula, Mexico breeding lagoons to identify matches between these two populations. A total of 14 matches of individuals were found, including six males, six females and two of unknown sex. Thirteen whales had sightings prior to and after to their respective sighting in Mexico. Thirteen whales were observed in Laguna San Ignacio and one in Laguna Ojo de Liebre. Eleven of the 14 whales were photographed in Mexico only in one year and the other 3 in two years. Thirteen whales were sighted in Sakhalin in the summer of 2011. Twelve whales were sighted in consecutive seasons, eight of them in three consecutive seasons (summer-winter-summer), three in two seasons (summer-winter), and five in two seasons (winter-summer). Three whales were sighted the same day in Laguna San Ignacio suggesting that these animals were traveling in association with each other. Five females with calves were sighted in the winter in Mexican waters and in the next summer off Sakhalin, three of them without calves suggesting that these females had either separated from their calves or that their calves did not survive. The time between the last sighting in one season and the first one in the next season was $\bar{x}=195.4$ days (n=11, 141-255) during the summer-winter migration, and $\bar{x}=165.6$ days (n=13, 131-213) during the winter-summer migration. The matches made between whales sighted off Sakhalin and the Mexican Pacific are the first results of the multinational collaboration "PACIFIC WIDE STUDY ON POPULATION STRUCTURE AND MOVEMENT PATTERNS OF NORTH PACIFIC GRAY WHALES" initiated under the coordination and support of the International Whaling Commission last year.

INTRODUCTION

Recent results of genetic and photographic identification comparisons between western and eastern North Pacific gray whales (see IWC, 2011) suggest a mixing of these populations during the winter reproductive season, and illustrate the great conservation and management importance of a more comprehensive examination of gray whale movement patterns and population structure in the North Pacific. The Scientific Committee recommended that a collaborative Pacific-wide study be developed under the auspices of the IWC, recognising that *inter alia* this will contribute to the Committee-

endorsed Conservation Plan for western North Pacific gray whales and incorporate previous recommendations made by the Committee. Such a study will involve collaborative analysis and sharing of existing data as well as the collection of new data. This report summarizes the results of the "(Phase 1) photo-identification project". The purpose of this project was to undertake a comparison of two western gray whale catalogues from Sakhalin Island, Russia with the Mexican gray whale catalogue.

METHODS

The comparison was done based on two catalogues of photo-identified gray whales from Sakhalin Island and one catalogue of gray whales from Laguna San Ignacio and Laguna Ojo the Liebre on the west coast of the Baja California Peninsula, México.

The Sakhalin catalogues

The first step was to compare the two catalogues available at that moment:

1) The Russia-US catalogue (2012).

Burdin, A. M., Weller, D., Sychenko, O., and Bradford, A. 2012. *"WESTERN GRAY WHALES OFF SAKHALIN ISLAND, RUSSIA: A CATALOG OF PHOTO-IDENTIFIED INDIVIDUALS"*.
205 individuals. Period 1994-2011
2) The IBM catalogue.

Tyurneva, O. Yu. and Yakovlev, Yu. M. 2010. "THE WESTERN PACIFIC GRAY WHALES OF SAKHALIN ISLAND 2002-2008, LEARING ABOUT A POPULATION OF WHALES THROUGH PHOTOGRAPHS".
165 individuals. Period: 2002-2008

As result of these comparisons 217 photo-identified gray whales from Sakhalin were used in the comparison with the Mexican catalogue. All are represented by the right-side dorsal flank and 215 are associated with the left-side dorsal flank

The Mexican catalogue

This catalogue includes 6,546 gray whales. 5366 photo-identified in Laguna San Ignacio between 1993 and 2011, and 1180 in Laguna Ojo de Liebre (Scammon´s Lagoon) between 2001 and 2003. Of the 6,546 whales in the catalogue 5,890 are represented by a right-side of the dorsal flank image and 1,837 were associated with a left-side dorsal flank image (Table 1).

Table 1. Number of photo-identified gray whales in the Mexican catalogue.
Laguna Ojo de Liebre = LOL, Laguna San Ignacio = LSI.

year	Total photo-id whales	Right and left sides	Only right side	Only left side	Lagoon
2001	398	0	398	0	LOL
2002	462	0	462	0	LOL
2003	320	0	320	0	LOL
1996	157	0	155	2	LSI
1997	310	0	310	0	LSI
1998	392	0	392	0	LSI
1999	253	0	253	0	LSI
2000	448	0	448	0	LSI
2003	247	0	247	0	LSI
2005	438	18	420	0	LSI
2006	249	22	226	1	LSI
2007	495	150	217	128	LSI
2008	358	114	137	107	LSI
2009	662	286	238	138	LSI
2010	750	250	319	181	LSI
2011	607	341	167	99	LSI
Total	**6546**	**1181**	**4709**	**656**	

RESULTS.

The Sakhalin to Mexico catalog comparison resulted in a total of 14 confirmed matches of individuals, including six males, six females and two of unknown sex. Thirteen whales had sightings prior and after to their respective sighting in Mexico. Twelve whales were observed in Laguna San Ignacio and one (#3) in Laguna Ojo de Liebre. Eleven of the 13 whales were photographed in Mexico only in one year and the other 3 in two years. Thirteen whales were sighted in Sakhalin in the summer of 2011(Table 2).

All fourteen whales were sighted in consecutive seasons, eight of them in three consecutive seasons (summer-winter-summer), three in two seasons (summer-winter), and six in two seasons (winter-summer). Whale #2, male, was sighted in summer-winter (2006-2007), and summer-winter-summer (2009-2010); the whale #9, female, was sighted in summer-winter-summer (2006-2007), and in the winter-summer (2011); and the whale #11, was sighted in summer-winter-summer (2007-2008), and in the summer-winter (2009-2010) (Table 3).

The whales #5, #6 and #12 were sighted the same day, February 24 2006, and whale # 20 was sighted two days later in Laguna San Ignacio. The whales #5 and #12 were in the same group and #6 in a different group, suggesting that these animals were traveling in association with each other (Table 3).

The six known females were sighted with calves in the winter in Mexican waters and in the next summer in their feeding grounds, three of them without calves (Table 3), suggesting that these females had either separated from their calves (e.g. weaned) or that their calves did not survive (e.g., due to predation).

The female #7 was observed with calf in March 11, 2009 in Laguna San Ignacio and 122 days later, on July 11, off the Kamchatka Peninsula where she stayed with her calf at least until September 2. The female #14 was observed with calf on February 17, 2011 in Laguna San Ignacio and 140 days later in Sakhalin Island.

The time between the last sighting in one season and the first one in the next season was $\bar{x}$=195.4 days (n=11, 141-255) during the summer-winter migration, and $\bar{x}$=165.6 days (n=13, 131-213) during the winter-summer migration. The shorter time between Laguna San Ignacio and Sakhalin was of the whale #13, of unknown sex, with 131 days followed by the whale #4, a male, with 139 days, and the whales #8, #11, and #14, mothers with calves, with 144, 143, and 140 days respectively (Table 3).Table 2. Sighting summary information for 13 gray whales matched between Sakhalin and Mexico. * = With calf.

	Russia-US		IBM		UABCS		Russia-US
#	**No.**	**Years**	**No.**	**Year(s)**	**No.**	**year(s)**	**Sex**
1[1]	20	97,02-04,07,09,11	80	06,07	06-0209-D-LSI	06	M
2[1]	52	98,99,00,01,02, 03,05,06,08,09,10,11	26	02,05,08	07-0328-I-LSI, 10-0639-D-LSI	07,10	M
3	27	95,97,98,99,00,01,02, 04,05,06,07,09,10,11	2	02,05	02-0336-D-LOL	02	M
4	91	00,05,07,08,09,11	137	07	11-0273-D-LSI	11	M
5	28	97,98,99,00,01,03,04, 05,06,07,09,11	59	05,07	06-0131-D-LSI	06	M
6	69	98,00,01,02,03,04, 08,09,11	113	04,05,07	06-0176-D-LSI	06	M
7[1]	42	97,98,99,00,03, 04,05,11	90	03,05,09*	09-0696-D-LSI-M	09*	F
8[1]	63	97,98*,00,01,02 05,07,08,10,11*	47	03,05,07	08-107-I-LSI-M	08*	F
9	103	01,02,04,05,11	119	05,06,07	07-0457-D-LSI, 11-0526-D-LSI-M	07,11*	F
10	29	97,98,00,01,02,03,04, 05,07,09,10,11	28	03,05	10-0739-D-LSI-M	10*	F
11	85	99,01,02,04,05,08*,09, 11	51	04,05,07	08-0051-D-LSI-M, 10-0396-D-LSI	08*,10	F
12	94	00,03,04,05,07,11	57	03,06,07,08	06-0132-D-LSI	06	U
13			166	09	09-0506-D-LSI	09	U
14	3	97,99,04,05,06,09	144	05,06,07,08,11*	11-0505-D-LSI-M	11*	F

[1]Reported in Weller *et al*. 2011, [2]Observed only off Kamchatka

Table 3. Gray whales sighted in consecutive seasons.

#	Sakhalin (Summer) RusUS	IBM	Mexico (Winter) UABCS	Sex	Summer	Days	Winter	Days	Summer
1	20	80	06-0209-D-LSI	M			26-Feb-2006	213	27-Sep-2006
2	52	26	07-0328-I-LSI, 10-0639-D-LSI	M	22-Aug-2006 07-Aug-2009	181 217	20-Feb-2007 13-Mar-2010	 177	 06-Sep-2010
3	27	2	02-0336-D-LOL	M	31-Jul-2001	217	06-Mar-2002	150	03-Aug-2002
4	91	137	11-0273-D-LSI	M			01-Mar-2011	139	18-Jul-2011
5	28	59	06-0131-D-LSI	M	07-Aug-2005	200	24-Feb-2006	179	22-Aug-2006
6	69	113	06-0176-D-LSI	M	23-Ags-2005	184	24-Feb-2006		
7	42	90	09-0696-D-LSI-M	F			11-Mar-2009*	122	11-Jul-2009*
8	63	47	08-107-I-LSI-M	F	09-Sep-2007°	201	29-Mar-2008*	144	20-Aug-2008°
9	103	119	07-0457-D-LSI, 11-0526-D-LSI-M	F	17-Oct-2006”	141	08-Mar-2007° 08-Mar-2011*	189 170	13-Sep-2007” 25-Aug-2011°
10	29	28	10-0739-D-LSI-M	F	07-Aug-2009°	219	14-Mar-2010* 29-Mar-2010*	176	06-Sep-2010°
11	85	51	08-0051-D-LSI-M, 10-0396-D-LSI	F	16-Sep-2007” 24-Jul-2009	163 255	26-Feb-2008* 06-Mar-2010*	143	19-Jul-2008*
12	94	57	06-0132-D-LSI	U	06-Sep-2005	171	24-Feb2006	203	16-sep-2006
13		166	09-0506-D-LSI	U			04-Mar-2009	131	113-Jul-2009
14	3	114	11-0505-D-LSI-M	F			17-Feb-2011*	140	07-Jul-2011*

*with calf
°without calf
“presence of calf unknown

DISCUSSION

The 14 individuals sighted in Mexican waters represent about 10% of the western gray whale population based on the population assessment of an estimate of 130 individuals (90% Bayesian CI = 120-142) (Cooke *et al.* 2008). If we combine these matches with the six matches found off the coast of Vancouver Island reported by Weller *et al.*, (2011), presumably during their migration from the breeding lagoons along the Mexican coast, and the two genetic matches noted by Lang *et al.*, (2011) with whales sampled in southern California, a total of 22 whales identified as part of the western gray whale population have migrated, at least in some years, to the eastern North Pacific during the winter breeding season.

The presence of three of these whales the same day in Laguna San Ignacio, two in the same group, indicate that these whales may travel in association or in groups, as Weller *et al.*, (2011) observed based on six matches off Vancouver Island, British Columbia, Canada. This also suggests that these whales may stay together in groups while on the breeding grounds.

The sex of the whales (six males, six females and two of unknown sex) indicates that both sexes, in approximately equal numbers, migrate to Mexican waters during the winter breeding season.

The sighting of females without their calves on the Russian feeding grounds suggests a high mortality of the calves, based on the small sample of four mothers with calf sighted in Laguna San Ignacio and the next summer off Sakhalin and one off Kamchatka (i.e., only a 50% survivorship). The long distance of their migratory destination compared to the Bering and Chukchi Seas could be an important factor in the survivorship of the calves. Alternatively, these females may have separated from their calves as the normal weaning process when the calves were of sufficient age to begin foraging for themselves.

The number of days between the last photograph of the season and the first one of the next season represents the maximum migration time and depends on the presence of the whale, the chance to find and photograph it, and the field work seasons of the different research teams. The shorter times observed between Laguna San Ignacio and Sakhalin, 131-143 days, could be close to the real migration times of these whales.

The matches made between whales sighted off Sakhalin and the Mexican Pacific are the first results of the multinational collaboration "PACIFIC WIDE STUDY ON POPULATION STRUCTURE AND MOVEMENT PATTERNS OF NORTH PACIFIC GRAY WHALES" initiated under the coordination and support of the International Whaling Commission last year. Additional comparisons and analyses of photographs from the Western and Eastern gray whales are ongoing and will include photographs from the IBM Sakhalin catalogue 2008-2011, IBM Kamchatka catalogue, and from Laguna San Ignacio and Bahia Magdalena winter aggregation and breeding areas, obtained during the winter 2012.

Acknowledgements

We wish to thank our field researchers and colleagues that assisted with the documentation of the gray whales in Laguna San Ignacio and Laguna Ojo de Liebre. We also thank The Ocean Foundation, and the World Wildlife Fund-Mexico for their support of the field work and analysis of our results. This research was conducted as part of the Laguna San Ignacio Ecosystem Science Program (LSIESP) under special scientific research permits No.SGPA/DGVS/11560/10 and SGPA/DGVS/00640/12from the Subsecretaría de Gestión Para La Protección Ambiental, Dirección General de Vida Silvestre, de Mexico.

References.

Cooke JG, Weller DW, Bradford AL, Burdin AM, Brownell RL, Jr. (2008) Population assessment of western gray whales in 2008. Paper SC/60/BRG11 presented to the International Whaling Commission Scientific Committee. [Available from http://www.iwcoffice.org/]

IWC (2011) Report of the 2011 IWC Scientific Committee. Tromso, Norway. [Available from http://www.iwcoffice.org/]

Lang AR, Weller DW, LeDuc R, Burdin AM, Pease VL, Litovka D, Burkanov V, Brownell, RL, Jr. (2011) Genetic analysis of stock structure and movements of gray whales in the eastern and western North Pacific. Paper SC/63/BRG10 presented to the International Whaling Commission Scientific Committee. [Available from http://www.iwcoffice.org/]

Weller, DW, Klimek, A., Bradford, A.L., Calambokidis, J., Lang, A.R., Gisborne, B., Burdin A.M, Szaniszlo, W., and Brownell RL, Jr. (2011) Movements of western gray whales from the Okhotsk Sea to the eastern North Pacific.

Paper SC/63/BRG6. 5pp Submitted to the International Whaling Commission Scientific Committee. [Available from http://www.iwcoffice.org/]

GRAY WHALE CENSUS AND BEHAVIOR STUDY
AMERICAN CETACEAN SOCIETY, LOS ANGELES CHAPTER
PT. VICENTE 1990-2011

DECEMBER 2011

Day	Observ Period	Total Hours	SOUTHBOUND Daily Sitngs	Daily Whales	Daily C/C
1	0545-1700	11.25	0	0	0
2	0600-1700	11.00	0	0	0
3	0545-1700	11.25	1	1	0
4	0600-1700	11.00	1	1	0
5	0600-1700	11.00	0	0	0
6	0545-1700	11.25	0	0	0
7	0600-1700	11.00	0	0	0
8	0545-1700	11.25	0	0	0
9	0600-1700	11.00	0	0	0
10	0515-1700	11.75	3	3	0
11	0600-1700	11.00	1	3	0
12	0600-1700	11.00	2	2	0
13	0545-1700	11.25	2	2	0
14	0600-1700	11.00	4	7	0
15	0530-1700	11.50	1	2	0
16	0600-1700	11.00	4	5	0
17	0545-1700	11.25	2	5	0
18	0600-1700	11.00	2	2	0
19	0615-1700	10.75	4	4	0
20	0530-1715	11.75	6	9	0
21	0600-1700	11.00	8	10	0
22	0530-1700	11.50	12	18	0
23	0600-1700	11.00	5	8	0
24	0530-1700	11.50	11	21	0
25	0545-1730	11.75	13	17	0
26	0600-1715	11.25	15	27	2
27	0530-1700	11.50	11	16	0
28	0600-1715	11.25	6	6	0
29	0600-1615	10.25	13	17	0
30	0615-1615	10.00	5	5	0
31	0530-1615	10.75	0	0	0
				191	

345.00 TOTAL HRS FOR MONTH

DECEMBER 2010

Day	Observ Period	Total Hours	SOUTHBOUND Daily Sitngs	Daily Whales	Daily C/C
1	0600-1700	11.00	0	0	0
2	0530-1700	11.50	0	0	0
3	0600-1700	11.00	0	0	0
4	0600-1700	11.00	0	0	0
5	0600-1700	11.00	0	0	0
6	0600-1700	11.00	0	0	0
7	0600-1700	11.00	0	0	0
8	0600-1700	11.00	0	0	0
9	0600-1700	11.00	0	0	0
10	0600-1700	11.00	0	0	0
11	0600-1700	11.00	0	0	0
12	0600-1700	11.00	0	0	0
13	0600-1700	11.00	1	1	0
14	0600-1700	11.00	0	0	0
15	0630-1700	10.50	0	0	0
16	0600-1700	11.00	0	0	0
17	0600-1700	11.00	0	0	0

18	0600-1700	11.00	2	3	0
19	0615-1700	10.75	1	1	0
20	0600-1700	11.00	0	0	0
21	0600-1700	11.00	4	7	0
22	0830-1700	8.50	2	3	0
23	0600-1700	11.00	1	1	0
24	0600-1700	11.00	3	5	0
25	0600-1700	11.00	2	4	0
26	0600-1700	11.00	1	1	0
27	0600-1700	11.00	4	6	0
28	0600-1700	11.00	0	0	0
29	0630-1700	10.50	3	4	0
30	0600-1700	11.00	2	2	0
31	0600-1700	11.00	0	0	0
				38	

337.75 TOTAL HRS FOR MONTH

DECEMBER 2009 SOUTHBOUND

Day	Observ Period	Total Hours	Daily Sitngs	Daily Whales	Daily C/C
1	0545-1700	11.25	1	2	0
2	0600-1700	11.00	0	0	0
3	0545-1700	11.25	0	0	0
4	0545-1700	11.25	0	0	0
5	0545-1700	11.25	0	0	0
6	0600-1700	11.00	0	0	0
7	0600-1700	11.00	1	1	0
8	0530-1700	11.50	0	0	0
9	0600-1700	11.00	0	0	0
10	0545-1700	11.25	0	0	0
11	0600-1700	11.00	0	0	0
12	0545-1700	11.25	0	0	0
13	0615-1700	10.75	0	0	0
14	0600-1700	11.00	0	0	0
15	0545-1700	11.25	0	0	0
16	0600-1700	11.00	1	2	0
17	0545-1700	11.25	2	2	0
18	0600-1700	11.00	0	0	0
19	0545-1700	11.00	0	0	0
20	0615-1700	10.75	0	0	0
21	0600-1700	11.00	1	1	0
22	0600-1645	10.75	0	0	0
23	0600-1700	11.00	1	1	0
24	0600-1700	11.00	1	1	0
25	0600-1700	11.00	4	4	0
26	0545-1700	11.25	1	2	0
27	0615-1730	11.25	1	1	0
28	0600-1700	11.00	1	2	0
29	0600-1700	11.00	1	2	0
30	0600-1700	11.00	1	1	0
31	0600-1700	11.00	0	0	0
				22	

343.25 TOTAL HRS FOR MONTH

DECEMBER 2008 SOUTHBOUND

Day	Observ Period	Total Hours	Daily Sitngs	Daily Whales	Daily C/C
1	0600-1700	11.00	0	0	0

2	0600-1700	11.00	0	0	0
3	0600-1700	11.00	1	3	0
4	0600-1700	11.00	0	0	0
5	0600-1700	11.00	0	0	0
6	0545-1700	11.25	0	0	0
7	0600-1700	11.00	3	6	0
8	0600-1700	11.00	1	2	0
9	0545-1700	11.25	1	3	0
10	0600-1700	11.00	2	3	0
11	0600-1700	11.00	0	0	0
12	0600-1700	11.00	1	1	0
13	0545-1715	11.50	2	4	0
14	0600-1700	11.00	1	1	0
15	0600-1700	11.00	1	3	0
16	0545-1700	11.25	2	3	0
17	0600-1700	11.00	1	2	0
18	0600-1700	11.00	1	1	0
19	0600-1700	11.00	1	3	0
20	0545-1700	11.25	3	4	0
21	0545-1700	11.25	3	7	0
22	0600-1700	11.00	0	0	0
23	0600-1700	11.00	1	2	0
24	0600-1700	11.00	1	1	0
25	0600-1700	11.00	1	1	0
26	0600-1700	11.00	3	3	0
27	0600-1700	11.00	2	4	1
28	0600-1700	11.00	0	0	0
29	0600-1700	11.00	0	0	0
30	0600-1700	11.00	3	3	0
31	0600-1700	11.00	2	2	0
		342.75	TOTAL HRS FOR MONTH	62	

DECEMBER 2007 SOUTHBOUND

Day	Observ Period	Total Hours	Daily Sitngs	Daily Whales	Daily C/C
1	0530-1700	11.50	0	0	0
2	0545-1700	11.25	0	0	0
3	0545-1700	11.25	0	0	0
4	0545-1700	11.25	0	0	0
5	0600-1700	11.00	0	0	0
6	0600-1700	11.00	0	0	0
7	0600-1700	11.00	0	0	0
8	0530-1700	11.50	2	13	0
9	0515-1700	11.75	0	0	0
10	0545-1700	11.25	0	0	0
11	0545-1700	11.25	1	1	0
12	0600-1700	11.00	1	1	0
13	0545-1700	11.25	0	0	0
14	0545-1700	11.25	0	0	0
15	0530-1700	11.50	0	0	0
16	0530-1700	11.50	1	1	0
17	0545-1700	11.25	1	1	0
18	0600-1600	10.00	1	1	0
19	0600-1700	11.00	0	0	0
20	0600-1645	10.75	0	0	0
21	0600-1715	11.25	1	2	0
22	0530-1700	11.50	0	0	0
23	0530-1700	11.50	1	1	0
24	0530-1700	11.50	1	1	0
25	0545-1700	11.25	3	7	0
26	0600-1700	11.00	1	1	0
27	0600-1715	11.25	1	1	0

28	0600-1700	11.00	0	0	0
29	0600-1700	11.00	1	1	0
30	0530-1700	11.50	1	1	0
31	0545-1715	11.50	1	1	0
				34	
		347.75	TOTAL HRS FOR MONTH		

Hunter Kilpatrick
2647 Greenwood Ave. #C
Morro Bay, Ca. 93442
October 11, 2012

P.Michael Payne
Chief
Permits & Conservation Division
Office of Protected Resources
1315 East-West Highway
Silver Spring, Md. 20910

Dear Mr. Payne:

I am submitting my comments to the proposed PG &E HESS off the central coast of California and in relation to the IHA - Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California, November to December, 2012.

I strongly urge the National Marine Fisheries Service to deny the current IHA permit application for the following reasons:

- The IHA is incomplete
    - California Gray whales will be migrating
        - Ignored in the take estimates and assumed to not be in the area and not endangered
        - 191 counted last year in December – documented ACS census (see attached)
    - Western Gray Whales
        - Highly endangered population with approx. 110 individuals left on the planet
        - 14 known to be migrating using the eastern migration route to lagoons in Mexico last year (greater than 10% of existing stock)
            - Documented photographic ID (see attached)
    - Migrating Northern Elephant Seals
        - Majority of population will be migrating through these waters in late November through mid-December to rookeries on the channel Islands
        - Pregnant females and bulls
            - Diversion of migration will cause births at sea and loss of newborns
            - Will force individuals into deeper waters lacking coastal protection from predators and be forced away from food sources
        - Stress and avoidance of sound will cause haul out on unsafe locations

    - IHA assumes the Sea Otters will leave the area for safety
        - Mothers with newborn pups will not be able to feed or flee
            - Starvation and disease will created great distress, harm and loss
    - California Sea Lions and Harbor Seals will be chased out of the water for at least 2 weeks
        - Causing malnutrition and illnesses
    - Invertebrates and Rock Fish can't just leave
        - Only fish that might be able to get out of the way are non-resident pelagic's
- IHA is assuming only "harassment Level B take"
    - Relocation, hauling out, forced into predatory water, disorientation, disruption or breeding and normal behavior will cause stress, malnutrition, injury, harm and mortality
    - **Clearly Level A Take** not Level B minor harassment
    - Application is for wrong "Take"
    - Clear violation of MMPA
- Mitigation plan is ineffective
    - Weekly aerial surveys over small area and on board observers will not see anything until it is already in harms way, already harmed or injured, and only properly could be spotted during daylight hours
    - Marine mammals migrating often cover great distance under the surface and will not be spotted
    - Diversion of normal migration routes will cause predation and harm
    - Sea Otter mitigation will only show damage done not prevent harm and take
- Sound will travel hundreds of miles and still be 120db as far away as 58.95 miles according to PGE report
    - Not taking in to count reflection of sea mount and through thermal inclines
- Scope of project has changed drastically since original application and new application reflecting the current project must be submitted
- EIR that was certified by California State Lands Commission is flawed, inaccurate and incomplete for same reasons and must be decertified and therefore not assumed to be valid by NMFS
- New project does not include the area of most concern
    - Shoreline and San Luis fault zones
    - Future projects must not be taken in to consideration as this IHA will expire and must be reapplied for at a future time
- Existing data and newly acquired data has yet to be thoroughly reviewed and analyzed as per AB1632 and the SEC analysis of AB1632

- Current low energy 3d survey has just been completed and PGE has commented to California Fish and Game will take at least one year to analyze
  - This data may produce the needed answers and therefore make the proposed project redundant and unnecessary

The proposed HESS is a flawed plan with incomplete application data and may prove to be unnecessary after recently acquired data and existing data are properly reviewed and analyzed as per AB1632 and CEC analysis. The Take permit is inaccurate and the wrong permit is applied for. For these reasons, the take and potential harm, injury and mortality of marine mammals may prove to be unnecessary and therefore avoidable and any permitting at this time will be in direct violation of the MMPA. Highly endangered species and many other species will be put at harm and at risk for Level A take.
The risk to an entire ecosystem is too great and the potential for a greater gain is too little to permit at this time.
Please urge PGE to complete the studies currently in progress before progressing to such a potentially damaging and destructive method of gaining what could be redundant, incomplete and unnecessary data.

Sincerely,

Hunter Kilpatrick

Hunter Kilpatrick
Marine Mammal docent, naturalist, informal educator and rescuer
805-772-7501
morrobayhunter@yahoo.com

California State Lands Commission, Attn: Jennifer DeLeon, Division of Environmental Planning and Management

Hello,

I am a specialist in the impacts of noise on marine mammals, having focused on this issue for the last 20 years. As a bioacoustician, studying whale sounds and communication for 30 years now, I am gravely concerned about seismic surveys and the dangers they pose for marine life.

I have put together a summary of impacts on marine life from seismic surveys, including the most recent literature. Please accept this e-mail and the below review as my comments on your Final EIR. I hope that the range of impacts, along with all the references, should give you pause and help you to understand the potential severity of environmental damage which is at stake.

Sincerely,

Lindy Weilgart, Ph.D.

A Review of the Impacts of Seismic Airgun Surveys on Marine Life

Lindy Weilgart, Ph.D.
Department of Biology
Dalhousie University
Halifax, Nova Scotia

and

Okeanos Foundation
Darmstadt, Germany

14 August 2012

Noise from a single seismic airgun survey, used to discover oil and gas deposits hundreds of kilometers under the sea floor, can blanket an area of over 300,000 km2, raising background noise levels 100-fold (20 dB), continuously for weeks or months (IWC 2005, IWC 2007). Since this exposes large portions of a cetacean population to chronic noise, the International Whaling Commission's Scientific Committee noted "…repeated and persistent acoustic insults [over] a large area…should be considered enough to cause population level impacts." (IWC 2005).

Nieukirk et al. (2012) analyzed 10 years of recordings from the Mid-Atlantic Ridge, finding that seismic airguns were heard at distances of 4,000 km from survey vessels and present 80-95% of the days/month for more than 12 consecutive months in some locations. When several surveys were recorded simultaneously, whale sounds were masked (drowned out), and the airgun noise became the dominant part of background noise levels.

To compare the total energy output per year (in joules) of the various human-made noise sources, the highest is 2.1 x 1015 J, representing the contribution from nuclear explosions and ship-shock trials (explosions used by the Navy to test the structural integrity of their ships). Immediately following in contribution are seismic airgun arrays at 3.9 x 1013 J. Next, are military sonars (2.6 x 1013 J) and supertankers, merchant vessels, and fishing vessels at 3.8 x 1012 J (Hildebrand 2005).

Marine mammals

Gordon et al. (2004) found that marine mammals can be impacted by the intense, broadband pulses produced by seismic airguns through hearing impairment (temporary or permanent threshold shift, TTS or PTS), physiological changes such as stress responses, indirectly by impacting their prey, behavioral alterations such as avoidance

responses, displacement, or a change in vocalizations, or through masking (obliterating sounds of interest). Humpback and fin whales appear to communicate over distances of at least tens of kilometers (e.g. Watkins and Schevill 1979), so reducing this distance would compromise their ability to communicate.

Around 250 male fin whales appeared to stop singing for several weeks to months during a seismic survey, resuming singing within hours or days after the survey ended (International Whaling Commission 2007). Assuming male fin whale songs have a reproductive function, such as attracting and finding mates (Croll et al. 2002), it would be difficult to believe that such an effect would not be biologically significant. McDonald et al. (1995) noted that a blue whale stopped calling in the presence of a seismic survey 10 km away.

A different blue whale population showed the opposite reaction. Even a seismic survey using a low-to-medium power sparker caused blue whales in the St. Lawrence Estuary to modify their vocalizations (Di Iorio and Clark 2010). Blue whales called consistently more on days when the seismic survey was operating than when not, and more during periods within those days in which the sparker was on vs. off. The number of blue whale calls increased within the 1-hr block after sparker onset. The authors postulated that the blue whales were attempting to compensate for the additional introduction of noise, and noted that whales probably received a fairly low level of noise (131 dB re 1 mPa (peak to peak) over 30–500 Hz, with a mean sound exposure level of 114 dB re 1 µPa2 s). Thus, they suggested that even low source level seismic survey noise could interfere with important signals used in social interactions and feeding (Di Iorio and Clark 2010).

Marine mammals also avoid seismic noise by vacating the area. Castellote et al. (2012) showed extended displacement of fin whales by a seismic survey which lasted well beyond the survey length. Weir (2008) found that Atlantic spotted dolphins showed stronger responses to seismic airgun exposure than humpback or sperm whales. These dolphins were found significantly farther away from the airguns when they were on vs. off and only approached the seismic vessel when the airguns were silent. An analysis of cetacean responses to 201 seismic surveys in UK waters exhibited evidence of disturbance (Stone and Tasker 2006). During active seismic surveying, all small odontocetes, killer whales, and all mysticetes were found at greater distances from the seismic vessel than when it was not shooting. Small odontocetes showed the greatest horizontal avoidance, which reached to the limit of visual observation. Sighting rates for mysticetes, sperm whales, pilot whales, and killer whales did not decrease when airguns were off vs. on, but mysticetes and killer whales showed localized avoidance. During seismic shooting, fewer animals appeared to be feeding, smaller odontocetes seemed to swim faster, and mysticetes appeared to remain longer at the surface where sound levels are lower. Reactions were stronger to larger volume seismic arrays. Stone and Tasker (2006) theorized that smaller odontocetes may vacate the area entirely during exposure to seismic, whereas slower-moving mysticetes may remain in the area, simply increase their distance from the noise.

Responses can differ according to context, sex, age class, or species. Bowhead whales avoided seismic air-gun noise at received levels of 120–130 dB (rms over pulse duration) during their fall migration, though they were much more tolerant of noise when feeding in the summer, staying away from levels of 158–170 dB, which are roughly 10 000 times more intense (Richardson et al. 1995, 1999). Humpback cows and calves in key habitat evaded seismic air guns at 140–143 dB re 1 µPa mean squared pressure, which was lower than the reaction of migrating humpbacks at 157–164 dB re 1 µPa mean squared pressure (McCauley et al. 2000). Species with similar hearing capabilities and audiograms showed markedly different responses to airgun noise off British Columbia, with harbor porpoises appearing to be the most sensitive, responding to seismic noise at distances of >70 km, at received levels of <145 dB re 1 µPa rms (Bain and Williams 2006; International Whaling Commission 2007).

Reactions to seismic airguns can also be quite subtle and hard to detect. Sperm whales in the Gulf of Mexico did not appear to avoid a seismic airgun survey, though they significantly reduced their swimming effort during noise exposure along with a tendency toward reduced foraging (Miller et al 2009). Miller et al. (2009) tagged 8 sperm whales with tags recording sounds and movement while exposing them to operating airgun arrays. The longest resting bout ever observed in any sperm whale (265 min.) happened to the whale most closely approached by the actively firing seismic survey vessel, with the whale finally diving 4 min. after the final airgun pulse. Whales significantly reduced their fluke stroke effort by 6% during exposure to seismic noise compared with after, and all seven sperm whales studied reduced their fluke strokes on foraging dives in the presence of seismic noise. Moreover, there were indications that prey capture attempts were 19% lower during airgun noise exposure

(Miller et al. 2009). The authors note that even small reductions in foraging rate could result in lower reproductive rates and have negative consequences for the population.

Though summering bowheads showed no detectable avoidance of seismic surveys, no change in general activities or call types, and no obvious alteration of calling rate, they dove for shorter periods and their respiration rate was lower than non-exposed bowheads (Richardson et al. 1986). Such changes were observed up to 54–73 km from seismic surveys at received levels that could be as low as <125 dB re 1 µPa (Richardson et al. 1995).

Seismic noise has been thought to at least contribute to some species' declines or lack of recovery (Weller et al. 2006a, 2006b; International Whaling Commission 2007). Critically endangered western gray whales off Sakhalin Island, Russia, were displaced by seismic surveys from their primary feeding area, returning only days after seismic activity stopped (International Whaling Commission 2005). This change in distribution closely followed the timing of the seismic surveys (International Whaling Commission 2005, 2007; Weller et al. 2006a). Whales exposed to seismic noise levels of about 153 dB re 1 µPa zero-to-peak and 159 dB peak-to-peak on their feeding grounds also swam faster and straighter over a larger area with faster respiration rates during seismic operations (Weller et al. 2006b; International Whaling Commission 2007).

Parente et al. (2007) discovered a reduction in cetacean species diversity with increasing numbers of seismic surveys during 2000 and 2001 off Brazil, despite no significant oceanographic changes in this period. Between 1999 and 2004, there was a negative relationship between cetacean diversity and the intensity of seismic surveys.

When exposed to a single airgun or small airgun array, gray seals showed avoidance and switched from foraging to transiting behavior. They also began hauling out, possibly to escape the noise. Harbor seals exhibited a slowing of their heart rate together with dramatic avoidance behavior and stopped feeding (Thompson et al. 1998).

Seismic air guns are a probable cause of whale strandings and deaths as well, especially in beaked whales (Hildebrand 2005). A stranding of two individuals was tied very closely in space and time to a seismic survey in the Gulf of California. Even if impacts are fatal, only 2% of all cetacean carcasses are detected, on average (Williams et al. 2011). The authors state that for cryptic mortality events such as acoustic trauma, analytical methods are necessary to take into consideration the small percentage of carcasses that will be recovered.

A pantropical spotted dolphin suffered rigidity and postural instability progressing to a catatonic-like state and probable drowning within 600 m of a 3D seismic survey firing at full power (Gray and Van Waerebeek 2011). The authors explained the initial aberrant behavior by a possible attempt by the dolphin to shield its sensitive rostrum and hearing structures from the intense acoustic energy of the airguns, by lifting its head above the water's surface. They believed the seismic survey could have caused this observed behavior, presumably resulting from severe acoustic distress and even injury.
Other explanations were examined and considered less likely (Gray and Van Waerebeek 2011).
Stress effects or physiological changes, if chronic, can inhibit the immune system or otherwise compromise the health of animals. These can be very difficult to detect in cetaceans. Indications of increased stress and a weakened immune system following seismic noise broadcasts were shown for a whale and dolphin (Romano et al. 2004). Loud, impulsive noise produced from a seismic water gun caused significantly increased mean norepinephrine, epinephrine, and dopamine levels immediately after a high, but not low-level exposure in a captive beluga whale (Romano et al. 2004). All three of these stress hormones increased significantly with increasing noise levels. These hormone levels remained high even 1 hour after noise exposure, which is surprising given their short half-life, according to the authors. In a captive bottlenose dolphin, the seismic water gun produced significant neuro-immune values, namely increases in aldosterone and a decrease in monocytes. Aldosterone is one of the principal stress hormones in cetaceans and may surpass cortisol as a more sensitive indicator of stress (Romano et al. 2004).

Mitigation measures to safeguard whales against high noise exposures are very inadequate. Generally, only the area within 500 m of the seismic vessel is observed, yet high noise levels can occur at much greater distances. Madsen et al. (2006) discovered that in the Gulf of Mexico received levels can be as high at a distance of 12 km from a seismic survey as they are at 2 km (in both cases >160 dB peak-to-peak). Received levels, as determined from acoustic tags on sperm whales, generally fell at distances of 1.4 to 6–8 km from the seismic survey, only to increase again at

greater distances (Madsen et al. 2006).

Moreover, determining an exposure level that is "safe" for marine mammals is fraught with difficulty. For instance, a harbor porpoise exposed to airgun pulses was found to have lower (more sensitive) masked TTS levels than any other cetacean that has been tested, namely 164.3 dB re 1 μPa2•s SEL or 199.7 dB pk-pk re 1 μPa (Lucke et al. 2009). The noise level required to cause hearing loss (temporary threshold shift or TTS) in whales is still very uncertain, especially for seismic airguns, as there are so few empirical measurements. Between-individual variability, the population's average sensitivity (how representative of the population was the tested animal), and the validity of extrapolating between species, particularly between captive small dolphins or porpoises (on which the few tests have been done) to free-ranging large baleen whales are all unknown. Gedamke et al. (2011) model how various factors and assumptions can change the percentage of whales exposed to damaging levels. When factoring in uncertainty and sources of variability, 29% (10-62%) of whales within 1-1.2 km of a seismic survey would experience levels sufficient to produce TTS onset. Without considering these factors, no whales beyond 0.6 km would be at risk for TTS, showing how even fairly small degrees of uncertainty can have a large effect on risk assessment (Gedamke et al. 2011). If management decisions are to be based on so little data, uncertainty must be taken into consideration. At close ranges, avoidance by whales of the seismic survey actually increased their exposure slightly as their speed was slower than the seismic vessel. Overall, Gedamke et al. (2011) concluded that TTS in baleen whales is plausible at ranges up to several kilometers.

Many (36-57%) of the stranded or entangled dolphins or toothed whales have been shown to have profound hearing loss, implying that impaired hearing could have led to their stranding/entanglement (Mann et al. 2010).

Marine Turtles

Marine turtles show a strong initial avoidance response to air-gun arrays at a strength of 175 dB re 1μPa rms or greater (O'Hara and Wilcox 1990; McCauley et al. 2000; Lenhardt 2002). Enclosed turtles also responded progressively less to successive airgun shots which may indicate reduced hearing sensitivity (TTS). One turtle experienced a TTS of 15dB, recovering two weeks later (Lenhardt 2002). McCauley et al. (2000) estimated that a typical airgun array operating in 100–120 m water depth could impact behavior at a distance of about 2 km and cause avoidance at around 1 km for marine turtles. DeRuiter and Doukara (2010) found that 51% of turtles dived at or before their closest point of approach to an airgun array.

Fish

A wide range of acoustic impacts on fish has been observed. Seismic air guns extensively damaged fish ears at distances of 500 m to several kilometres from seismic surveys. No recovery was apparent 58 days after exposure (McCauley et al. 2003). Behavioral reactions of fish to anthropogenic noise include dropping to deeper depths, milling in compact schools, ‘‘freezing’’, or becoming more active (Dalen and Knutsen 1987; Pearson et al. 1992; Skalski et al. 1992; Santulli et al. 1999; McCauley et al. 2000; Slotte et al. 2004). Reduced catch rates of 40%–80% and decreased abundance have been reported near seismic surveys in species such as Atlantic cod, haddock, rockfish, herring, sand eel, and blue whiting (Dalen and Knutsen 1987; Løkkeborg 1991; Skalski et al. 1992; Engås et al. 1996; Hassel et al. 2004; Slotte et al. 2004). These effects can last up to 5 days after exposure and at distances of more than 30 km from a seismic survey. The impacts of seismic airgun noise on eggs and larvae of marine fish included decreased egg viability, increased embryonic mortality, or decreased larval growth when exposed to sound levels of 120 dB re 1 μPa (Kostyuchenko 1973; Booman et al. 1996). Turbot larvae showed damage to brain cells and neuromasts (Booman et al. 1996). Neuromasts are thought to play an important role in escape reactions for many fish larvae, and thus their ability to avoid predators. Increases in stress hormones have been observed in fish due to noise (Santulli et al. 1999).

Invertebrates

Invertebrates also do not appear to be immune from the effects of anthropogenic noise. Nine giant squid mass stranded, some of them live, together with geophysical surveys using air guns in 2001 and 2003 in Spain (Guerra et al. 2004). The squid all had massive internal injuries, some severe, with internal organs and ears badly

damaged. Another species of squid exposed to airgun noise showed an alarm response at 156-161 dB rms and a strong startle response involving ink ejection and rapid swimming at 174 dB re 1µPa rms (McCauley et al. 2000). Caged squid also tried to avoid the noise by moving to the acoustic shadow of the cage. McCauley et al. (2000) suggest that the behavioral threshold for squid is 161-166 dB rms. A bivalve, Paphia aurea, showed acoustic stress as evidenced by hydrocortisone, glucose, and lactate levels when subjected to seismic noise (Moriyasu et al. 2004). Catch rates also declined with seismic noise exposure in Bolinus brandaris, a gastropod, the purple dye murex (Moriyasu et al. 2004). In snow crab, bruised ovaries and injuries to the equilibrium receptor system or statocysts were also observed (Department of Fisheries and Oceans 2004). Seismic noise-exposed crabs showed sediments in their gills and statocysts, and changes consistent with a stress response compared with control animals.

References

Bain, D.E. and Williams, R. 2006: Long-range effects of airgun noise on marine mammals: Responses as a function of received sound level and distance. International Whaling Commission Scientific Committee document IWCSC/58E35.

Booman, C., Dalen, J., Leivestad, H, Levsen, A., van der Meeren, T. and Toklum, K. 1996. Effects from airgun shooting on eggs, larvae, and fry. Experiments at the Institute of Marine Research and Zoological Laboratorium, University of Bergen. (In Norwegian. English summary and figure legends). Fisken og havet No. 3. 83 pp.

Castellote, M., Clark, C.W., and Lammers, M.O. 2012. Acoustic and behavioural changes by fin whales (Balaenoptera physalus) in response to shipping and airgun noise. Biological Conservation 147: 115–122.

Croll, D.A., Clark, C.W., Acevedo, A., Tershy, B., Flores, S., Gedamke, J., and Urban, J. 2002. Only male fin whales sing loud songs. Nature (London), 417: 809. doi:10.1038/417809a. PMID:12075339.

Dalen, J., and Knutsen, G.M. 1987. Scaring effects on fish and harmful effects on eggs, larvae and fry by offshore seismic explorations. In Progress in underwater acoustics. Edited by H.M. Merklinger. Plenum Press, New York. pp. 93–102.

Department of Fisheries and Oceans. 2004. Potential impacts of seismic energy on snow crab. DFO Can. Sci. Advis. Sec. Habitat Status report No. 2004/003.

DeRuiter, S.L. and Doukara, R.L 2010. Loggerhead turtles dive in response to airgun sound exposure. (ASA abstract).

Di Iorio, L. and Clark, C.W. 2010. Exposure to seismic survey alters blue whale acoustic communication. Biol. Lett. 6 (1): 51-54. doi:10.1098/rsbl.2009.0651

Engås, A., Løkkeborg, S., Ona, E., and Soldal, A.V. 1996. Effects of seismic shooting on local abundance and catch rates of cod (Gadus morhua) and haddock (Melanogrammus aeglefinus). Can. J. Fish. Aquat. Sci. 53: 2238–2249. doi:10.1139/cjfas-53-10-2238.

Engås, A. and Løkkeborg, S. 2002. Effects of seismic shooting and vessel-generated noise on fish behaviour and catch rates. Bioacoustics 12, 313–315.

Gedamke, J., Gales, N., and Frydman, S. 2011. Assessing risk of baleen whale hearing loss from seismic surveys: the effect of uncertainty and individual variation J. Acoust. Soc. Am. 129 (1): 496–506.

Gordon, J., Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R., and Tompson, D. 2004. A review of the effects of seismic surveys on marine mammals. Mar. Technol. Soc. J. 37(4): 16–34.

Gray, H., and Van Waerebeek, K. 2011. Postural instability and akinesia in a pantropical spotted dolphin, Stenella attenuata, in proximity to operating airguns of a geophysical seismic vessel. J. Nat. Cons. 19 (6): 363-367.

doi:10.1016/j.jnc.2011.06.

Guerra A, González AF, and Rocha F. 2004. A review of records of giant squid in the north-eastern Atlantic and severe injuries in Architeuthis dux stranded after acoustic exploration. ICES CM 2004/CC: 29.

Hassel, A., Knutsen, T., Dalen, J., Skaar, K., Løkkeborg, S., Misund, O.A., Østensen, Ø., Fonn, M., and Haugland, E.K. 2004. Influence of seismic shooting on the lesser sandeel (Ammodytes marinus). ICES J. Mar. Sci. 61: 1165–1173. doi:10.1016/j.icesjms.2004.07.008.

Hildebrand, J. A. 2005. Impacts of anthropogenic sound. In: Reynolds, J.E. et al. (eds.), Marine mammal research: conservation beyond crisis. The Johns Hopkins University Press, Baltimore, Maryland, pp. 101-124.

International Whaling Commission (IWC). 2005. Report of the scientific committee. Annex K. Report of the Standing Working Group on environmental concerns. J. Cetacean Res. Manag. 7 (Suppl.): 267–305.

International Whaling Commission (IWC). 2007. Report of the scientific committee. Annex K. Report of the Standing Working Group on environmental concerns. J. Cetacean Res. Manag. 9 (Suppl.): 227–296.

Kostyuchenko, L.P. 1973. Effects of elastic waves generated in marine seismic prospecting of fish eggs in the Black Sea. Hydrobiol. Jour. 9 (5): 45-48.

Lenhardt, M. 2002. Sea turtle auditory behavior. J. Acoust. Soc. Amer. 112(5, Pt. 2):2314 (Abstract).

Løkkeborg, S. 1991. Effects of a geophysical survey on catching success in longline fishing. ICES C.M. B: 40.

Lucke, K., Siebert, U., Lepper, P. A., and Blanchet, M. 2009. Temporary shift in masked hearing thresholds in a harbour porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli. J. Acoust. Soc. Am. 125: 4060–4070.

Madsen, P.T., Johnson, M., Miller, P.J.O., Aguilar Soto, N., Lynch, J., and Tyack, P. 2006. Quantitative measures of air-gun pulses recorded on sperm whales (Physeter macrocephalus) using acoustic tags during controlled exposure experiments. J. Acoust. Soc. Am. 120: 2366–2379. doi:10.1121/1.2229287.

Mann, D., Hill-Cook, M., Manire, C., Greenhow, D., Montie, E., Powell, J., Wells, R., Bauer, G., Cunningham-Smith, P., Lingenfelser, R., DiGiovanni, Jr., R., Stone, A., Brodsky, M., Stevens, R., Kieffer, G., and Hoetjes, P. 2010. Hearing loss in stranded odontocete dolphins and whales. PLoS ONE 5(11): 1-5. e13824. doi:10.1371/journal.pone.0013824.

McCauley, R.D., Duncan, A.J., Penrose, J.D., et al. 2000. Marine seismic surveys – a study of environmental implications. APPEA J 40: 692–706.

McCauley, R. D., Fewtrell, J., and Popper, A. N. 2003. High intensity anthropogenic sound damages fish ears. Journal of the Acoustical Society of America 113: 638–642.

McDonald, M. A., Hildebrand, J. A., and Webb, S. C. 1995. Blue and fin whales observed on a seafloor array in the Northeast Pacific. J. Acoust. Soc. Am. 98: 712–721.

Miller P.J.O , Johnson, M.P., Madsen, P.T., Biassoni, N., Quero, M. and Tyack, P.L. 2009. Using at-sea experiments to study the effects of airguns on the foraging behaviour of sperm whales in the Gulf of Mexico. Deep-Sea Research I 56 (7): 1168–1181. doi:10.1016/j.dsr.2009.02.008.

Moriyasu, M., Allain, R., Benhalima, K., and Claytor, R. 2004. Effects of seismic and marine noise on invertebrates: A literature review. Canadian Science Advisory Secretariat. Research document 2004/126.

Nieukirk, S.L., Mellinger, D.K., Moore, S.E., Klinck, K., Dziak, R.P., and Goslin, J. 2012. Sounds from airguns and fin whales recorded in the mid-Atlantic Ocean, 1999–2009. J. Acoust. Soc. Am. 131 (2): 1102–1112.

O'Hara, J. and J.R. Wilcox. 1990. Avoidance responses of loggerhead turtles, Caretta caretta, to low frequency sound. Copeia 1990 (2): 564-567.

Parente, C.L., Araújo, J.P. and Araújo, M.E. 2007. Diversity of cetaceans as tool in monitoring environmental impacts of seismic surveys. Biota Neotrop. 7 (1): 49-55. http://www.biotaneotropica.org.br/v7n1/pt/abstract?article+bn01307012007.

Pearson, W.H., Skalski, J.R., and Malme, C.I. 1992. Effects of sounds from a geophysical survey device on behavior of captive rockfish (Sebastes spp.). Can. J. Fish. Aquat. Sci. 49: 1343–1356.

Richardson, W.J., Malme, C.I., Green, C.R., Jr., and Thomson, D.H. 1995. Marine Mammals and Noise. Academic Press, San Diego, CA 576 pp.

Richardson, W.J., Miller, G.W., and Greene, C.R. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. J. Acoust. Soc. Am. 106: 2281. [Abstract only.] doi:10.1121/1.427801.

Richardson, W.J., Würsig, B., and Greene, C.R., Jr. 1986. Reactions of bowhead whales, Balaena mysticetus, to seismic exploration in the Canadian Beaufort Sea. J. Acoust. Soc. Am. 79: 1117–1128. doi:10.1121/1.393384.

Romano, T.A., Keogh, M.J., Kelly, C., Feng, P., Berk, L., Schlundt, C.E., Carder, D.A., and Finneran, J.J. 2004. Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. Can. J. Fish. Aquat. Sci. 61: 1124–1134. doi:10.1139/f04-055.

Santulli, A., Modica, A., Messina, C., Ceffa, L., Curatolo, A., Rivas, G., Fabi, G., and D'amelio, V. 1999. Biochemical responses of European sea bass (Dicentrarchus labrax L.) to the stress induced by off shore experimental seismic prospecting. Mar. Pollut. Bull. 38: 1105–1114. doi:10.1016/S0025-326X(99)00136-8.

Skalski, J.R., Pearson, W.H., and Malme, C.I. 1992. Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (Sebastes spp.). Can. J. Fish. Aquat. Sci. 49: 1357–1365.

Slotte, A., Hansen, K., Dalen, J., and One, E. 2004. Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast. Fish. Res. 67: 143–150. doi:10.1016/j.fishres.2003.09.046.

Stone, C.J., and Tasker, M.L. 2006. The effect of seismic airguns on cetaceans in UK waters. J. Cetacean Res. Manag. 8: 255–263.

Thompson, D., Sjoberg, M., Bryant, M.E., Lovell, P., and Bjorge, A. 1998. Behavioural and physiological responses of harbour (Phoca vitulina) and grey (Halichoerus grypus) seals to seismic surveys. Report to European Commission of BROMMAD Project. MAS2 C7940098.

Watkins, W. A., and Schevill, W. E. 1979. Aerial observation of feeding behavior in four baleen whales: Eubalaena glacialis, Balaenoptera borealis, Megaptera novaeangliae, and Balaenoptera physalus. J. Mammal. 60: 155–163.

Weir, C.R. 2008. Overt responses of humpback whales (Megaptera novaeangliae), sperm whales (Physeter macrocephalus), and Atlantic spotted dolphins (Stenella frontalis) to seismic exploration off Angola. Aquat. Mamm. 34(1): 71-83. DOI 10.1578/AM.34.1.2008.71

Weller, D.W., Rickards, S.H., Bradford, A.L., Burdin, A.M., and Brownell, R.L., Jr. 2006a . The influence of 1997

seismic surveys on the behavior of western gray whales off Sakhalin Island, Russia. Paper No. SC/58/E4 presented to the International Whaling Commission Scientific Committee, Cambridge, UK.

Weller, D.W., Tsidulko, G.A., Ivashchenko, Y.V., Burdin, A.M., and Brownell, R.L., Jr. 2006b . A re-evaluation of the influence of 2001 seismic surveys on western gray whales off Sakhalin Island, Russia. Paper No. SC/58/E5 presented to the International Whaling Commission Scientific Committee, Cambridge, U.K.

Williams, R., Gero, S., Bejder, L., Calambokidis, J., Kraus, S.D., Lusseau, D., Read, A.J., and Robbins, J. 2011. Underestimating the damage: interpreting cetacean carcass recoveries in the context of the Deepwater Horizon/BP incident. Conservation Letters 4: 228–233.

Lindy Weilgart, Ph.D.
Research Associate
Department of Biology
1355 Oxford St.
P.O. Box 15000
Dalhousie University
Halifax, Nova Scotia B3H 4R2 Canada
E-mail: lweilgar@dal.ca
Tel: 902-403-9377
Fax: 902-494-3736
http://whitelab.biology.dal.ca/lw/lindy.htm

and

Okeanos - Stiftung für das Meer
Foundation for the Sea
Auf der Marienhoehe 17
D - 64297 Darmstadt, Germany
http://www.okeanos-stiftung.org/homepage/
http://www.okeanos-stiftung.org/topics-and-projects/symposia/

----- End forwarded message -----

Lindy Weilgart, Ph.D.
Research Associate
Department of Biology
1355 Oxford St.
P.O. Box 15000
Dalhousie University
Halifax, Nova Scotia B3H 4R2 Canada
E-mail: lweilgar@dal.ca
Tel: 902-403-9377
Fax: 902-494-3736
http://whitelab.biology.dal.ca/lw/lindy.htm

and

Okeanos - Stiftung für das Meer
Foundation for the Sea
Auf der Marienhoehe 17
D - 64297 Darmstadt, Germany

http://www.okeanos-stiftung.org/homepage/
http://www.okeanos-stiftung.org/topics-and-projects/symposia/

ISSN 0889-3667
IJCP 20(2-3)89-316 (2007)

International Journal of Comparative Psychology

Published by the

International Society for Comparative Psychology

Stan Kuczaj, *Editor*

Considerations of the Effects of Noise on Marine Mammals and other Animals

Andrew J. Wright and Lauren Highfill, *Guest Editors*

2007, Volume 20, Numbers 2-3

Editor:

Stan Kuczaj
Department of Psychology
University of Southern Mississippi
118 College Drive #5025
Hattiesburg, MS 39406, U.S.A.
ijcp.editor@gmail.com

Guest Editors:

Andrew J. Wright
Leviathan Sciences

Lauren Highfill
University of Southern Mississippi

Editorial Advisory Board:

Michael J. Beran, *Georgia State University, U.S.A.*

Aaron P. Blaisdell, *University of California at Los Angeles, U.S.A.*

Daniela Brunner, *PsychoGenics and Columbia University, U.S.A.*

Jonathon D. Crystal, *University of Georgia, U.S.A.*

Nancy K. Dess, *Occidental College, U.S.A.*

Fabiana Kubke, *University of Auckland, New Zealand*

Suzanne E. MacDonald, *York University, Canada*

Lori Marino, *Emory University, U.S.A.*

Helena Matute, *Deusto University, Spain*

Roger Mellgren, *University of Texas at Arlington, U.S.A.*

Alba E. Mustaca, *University of Buenos Aires, Argentina*

Sadahiko Nakajima, *Kwansei Gakuin University, Japan*

Sergio M. Pellis, *University of Lethbridge, Canada*

Irene Pepperberg, *Harvard University, U.S.A.*

Steve Reilly, *University of Illinois at Chicago, U.S.A.*

Todd R. Schachtman, *University of Missouri, U.S.A.*

Roger K. R. Thompson, *Franklin and Marshall College, U.S.A.*

Masaki Tomonaga, *Kyoto University, Japan*

Editorial Assistants:

Kelly Caffery and Lauren Miller

International Journal of Comparative Psychology

2007, Volume 20, Number 2-3

Copyright © 2007 by the International Society for Comparative Psychology

III **Noise-Related Stress and Marine Mammals: An Introduction**
Andrew J. Wright and Lauran Highfill

89 Endocrinology of stress
L. Michael Romero and Luke K. Butler

96 From Classic Aspects of the Stress Response to Neuroinflammation and Sickness: Implications for Individuals and Offspring
Terrence Deak

111 The Behavioral Ecology of Disturbance Responses
Colin M. Beale

121 A Brief Review of Anthropogenic Sound in the Oceans
Leila Hatch and Andrew J. Wright

134 Effects of Noise on Rodent Physiology
Ann Linda Baldwin

145 The Effect of Transportation Noise on Health and Cognitive Development: A Review of Recent Evidence
Charlotte Clark and Stephen A. Stansfeld

159 A Brief Review of Known Effects of Noise on Marine Mammals
Linda S. Weilgart

169 Environmental Noise and Decision Making: Possible Implications of Increases in Anthropogenic Noise for Information Processing in Marine Mammals
Melissa Bateson

179 The Influence of Metal Pollution on the Immune System: A Potential Stressor for Marine Mammals in the North Sea
Antje Kakuschke and Andreas Prange

194 Potential Synergism between Stress and Contaminants in Free-ranging Cetaceans
Daniel Martineau

217 Fishery Effects on Dolphins Targeted by Tuna Purse-seiners in the Eastern Tropical Pacific Ocean
Elizabeth F. Edwards

228 The Long-term Consequences of Short-term Responses to Disturbance Experiences from Whalewatching Impact Assessment
David Lusseau and Lars Bejder

237 Adaptive Management, Population Modeling and Uncertainty Analysis for Assessing the Impacts of Noise on Cetacean Populations
Brendan A. Wintle

250 Anthropogenic noise as a stressor in animals: a multidisciplinary perspective
Andrew J. Wright, Natacha Aguilar Soto, Ann L. Baldwin, Melissa Bateson, Colin M. Beale, Charlotte Clark, Terrence Deak, Elizabeth F. Edwards, Antonio Fernández, Ana Godinho, Leila Hatch, Antje Kakuschke, David Lusseau, Daniel Martineau, L. Michael Romero, Linda Weilgart, Brendan Wintle, Giuseppe Notarbartolo-di-Sciara, and Vidal Martin

274 Do marine mammals experience stress related to anthropogenic noise?
Andrew J. Wright, Natacha Aguilar Soto, Ann L. Baldwin, Melissa Bateson, Colin M. Beale, Charlotte Clark, Terrence Deak, Elizabeth F. Edwards, Antonio Fernández, Ana Godinho, Leila Hatch, Antje Kakuschke, David Lusseau, Daniel Martineau, L. Michael Romero, Linda Weilgart, Brendan Wintle, Giuseppe Notarbartolo-di-Sciara, and Vidal Martin

The International Journal of Comparative Psychology is sponsored by the International Society for Comparative Psychology, an affiliate of the International Union of Psychological Sciences. In consonance with the goals and activities of the Society, it publishes studies on the evolution and development of behavior, broadly defined, and in all animal species; on the use of the comparative method for the understanding of behavioral processes; and the examination of the adequacy of psychological and evolutionary theories. It accepts for review articles that deal with historical and contemporary relationships between humans and other animals that elucidate problems of ecological and behavioral processes in resource management that explicate fundamental concepts about human evolution, and that present research results and develop theories about the development and evolution of behavior. The Editor is elected by the Operations Committee of the Society. The Editorial Advisory Board is appointed by the Editor and the Operations Committee.

Manuscripts can only be submitted electronically (MS Word, preferred). The *IJCP* adheres to APA format (see inside back cover for further details).

Copyright © 2007 by the International Society for Comparative Psychology.

Published quarterly.
ISSN 0889-3667 IJCPE820(2-3)89-316(2007)

Noise-Related Stress and Marine Mammals: An Introduction

Andrew J. Wright and Stan Kuczaj

Marine mammals (especially cetaceans) use sound as their primary sensory input for social communication, foraging, and other vital life-processes. Background noise has the potential to interfere with these functions by masking normal sounds, and at least some noise sources have been linked to behavioral and physiological responses (with lethal and non-lethal consequences). Consequently, it is reasonable to assume that at least some acoustic sources may act as stressors (stimuli leading to a stress response) for marine mammals.

The notion that noise may act as a stressor for free-ranging marine mammals is not a new one. Several reports and reviews in both the noise and the stress literature have mentioned this possibility (e.g., Richardson et al., 1995; Fair & Becker 2000; NRC 2003, 2005; Nowacek et al., 2007). The most common conclusion in this literature is that very little is known regarding marine mammal stress responses to noise. The most common recommendation is that more data be gathered. As a result, managers have been left with little information to guide their decisions.

There are large gaps in our knowledge about the particular physiological effects that chronic, repetitive or even acute noise exposures may have on cetaceans and other marine mammals. Experiments with captive animals alone are unlikely to bridge this gap, given the ethical dilemmas that arise when one considers exposing animals to potentially harmful levels of noise. Nonetheless, we suspect that studies with captive animals will prove valuable in ascertaining the more subtle effects of noise, such as masking and interference with cognitive processing. Given the paucity of data specific to marine mammals, evidence gathered from other animal populations might constitute a baseline on which to ground hypotheses regarding the likelihood of cetaceans to experience similar stress processes.

To initiate such a transfer of information, Dokumentes des Meeres (www.sound-in-the-sea.org), as part of its ongoing project on anthropogenic noise and marine mammals, brought a number of marine mammal scientists together with a diverse range of experts from other fields to discuss the impacts of noise. The objectives of the workshop were twofold:

- to identify the potential and likely consequences of noise-induced stress for individual animals and the populations to which they belong; and
- to determine the likelihood that, and the ways in which, noise exposure may induce stress responses in marine mammals based on of what is known about the effects of noise on humans and other animals in addition to the available information for marine mammals.

These discussions are represented in two papers in this issue. The first summarizes what is known about the physiological stress response, the initiation of that response by anthropogenic noise, the importance of context (physiological, psychological and environmental) in the stress response, and the ways that noise itself can change that context (Wright et al., this issue, a). The contents of this paper are broad and it is hoped that the conclusions and findings will be of use to anyone that studies or manages any species that may be subject to disturbance by

anthropogenic activities. The second paper applies to marine mammals the concepts brought together in the first, drawing on what is known about the responses of marine mammals to noise as well as other anthropogenic activities (Wright et al., this issue, b). Important contextual considerations specific to marine mammals are also discussed, and a collection of key findings and research recommendations are offered. Finally, a summary table is provided in the appendix with examples of the various known effects of stressors on an array of animals for easy comparison.

Definitions

It became clear very early on in discussions at the workshop that the disparate fields of science often used terminology in slightly, but notably, different ways. A related issue arose from the different measures of sound in air and in water, as well as conversions between the two. The latter issue is considered by Hatch & Wright (this issue), and in more detail in the references therein. However, as the discussions surrounding the terms 'stress' and 'habituation' could have lasted for the entire duration of the workshop, participants agreed to disagree, but also to adopt a set of working definitions for the purposes of the workshop.

What is stress?

Early discussions quickly revealed that participants were using the term 'stress' in a number of different ways, as discussed by Romero (2004). These included referring to:

- the threatening[1] stimuli to which an individual is exposed;
- the physiological and behavioral coping responses to those stimuli; and
- the over-stimulation of the coping responses that results in disease.

To allow for a productive dialogue the participants decided to adopt the terminology and definitions provided in Romero (2004) to distinguish between these different meanings. Consequently, we use 'stressor' to refer to a threatening stimulus, 'stress response' to refer to the various physiological and behavioral coping mechanisms, and 'chronic stress' to refer to long-term over-stimulation of coping responses. We also use the term 'stressed' (sparingly) to refer to an individual that is already experiencing a stress response that may either be chronic or acute.

The participants adopted these as working definitions while recognizing that the biomedical community itself is debating the various terminology, with the controversial concepts of 'allostasis', 'allostatic load' and 'allostatic overload' being recently proposed by McEwen & Wingfield (2003, summarized briefly below and in more detail by NRC 2005 and Romero 2004). This adoption does not represent agreement by any participant of those definitions, simply recognition that common ground would be required as we moved forward with our discussions.

[1] Romero (2004) used 'noxious' instead of 'threatening'. However, the term noxious is often used to refer specifically to painful stimuli. Noxious stimuli will certainly provoke a stress response, but many stressors represent psychological or physiological threats in the absence of overt pain.

Allostasis

Allostasis is the maintenance of homeostasis within a changing life-cycle and environment. Animals may build up an 'allostatic load' when they must work harder and/or consume more to handle a normal life-history task (such as breeding or migration) or deal with some additional drain on their energy budget. When they are no longer able to fully offset the additional demands they enter a state of 'allostatic overload', the state in which energy requirements exceed the capacity of the animal to replace that energy from environmental resources (a 'stressed' state). Consequently, McEwen & Wingfield (2003) proposed that 'stress' only be used to refer to stimuli that require an emergency energetic response (i.e., when stimuli push the animal into a state of allostatic overload).

Allostasis does not easily consider effects without direct (if any) energetic consequences, such as loss of sleep and missed opportunity costs. As a result it is central to an ongoing debate in the biomedical world. Although this was all discussed at the workshop, the participants did not want to enter into the debate, but simply to recognize that it exists.

What is habituation?

Habituation has a specific and consistent meaning in the psychological literature: "the gradual weakening of a response to a recurring stimulus" (e.g., Domjan, 2005; Kuczaj & Xitco, 2002). Similarly, Telch, Valentiner, Ilai, Petruzzi & Hehmsoth (2000) defined physiological habituation as the "reduction of arousal that results in a disassociation between the stimulus and response propositions". It was noted at the workshop that it is possible for overt responses to weaken without an associated reduction in physiological response. It is thus not surprising that the term "habituation" has been used in a variety of ways by those who study marine mammals, partly due to the fact that this taxonomic discipline brings together scientists with a variety of different backgrounds. Furthermore, the term "habituation" is also often invoked without reference to the literature and seemingly in conflict with the use of the term in the biomedical or psychological literature (see Bejder et al., 2006). Consequently, it has on occasion been used seemingly to demonstrate the end of impact, despite the fact that the psychological literature recognizes that habituation can be a negative consequence in itself. For example, the U.S. Minerals Management Service, Alaska Outer Continental Shelf Region (MMS Alaska OCS Region), noted in their discussion of the likely effects of the planned Oil and Gas Lease Sale 193 in the Chukchi that as "other cetaceans seem to habituate somewhat to continuous or repeated noise exposure when the noise is not associated with a harmful event, this suggests that bowheads will habituate to certain noises that they learn are nonthreatening" (MMS Alaska OCS Region 2007, pp IV-105). A precise definition or source is never offered, however it is noted in the same report that certain birds "become habituated to shipping activity… and spend the summer nesting or living nearby without apparent harm" (MMS Alaska OCS Region 2007, pp IV-196). This latter comment suggests that MMS are equating a habituated animal with one that is unaffected by further exposure to the stressor concerned.

Workshop participants were generally in disagreement with the idea that a behaviorally habituated animal is unaffected by a stressor. However, they also disagreed about which specific definition of habituation should be used. Guidance was provided by Romero (2004), who presented a definition for the related term "acclimation" as to be when an animal no longer responds physiologically in the same robust manner to repeated or chronic stressors, such as repeated handling. In acclimation, the psychological context of the stressor has effectively changed: the stimulus is no longer threatening to the animal and the physiological stress response is reduced. However, it should be noted that there are situations where a reduction in behavioral response can occur without an associated reduced physiological response, as discussed in more detail by Wright et al. (this issue, a).

Psychologists will recognize that Romero's definition of acclimation is in fact the definition of habituation (albeit focused on the physiological response), and undoubtedly wonder why acclimation was preferred to habituation. Suffice it to say that some workshop participants wished to distinguish themselves from the various perceived misuses of the term "habituation" by others, especially pertaining to the management of marine mammals, and so acclimation was viewed as a less controversial term.

An organism sometimes becomes acclimated to one stimulus but then shows sensitization to a perceivably different stimulus presented at some later time (see Domjan, 2005; Romero, 2004). The acclimation process can alter the animals' physiology such that responses to novel stressors are enhanced compared to responses of non-acclimated animals. This process is known as "sensitization" or "facilitation" and it occurs frequently, although not always, as a result of acclimation. For example, if rats exposed to repeated handling are then transferred to a novel environment their physiological stress response is higher than in naïve controls (Dallman et al., 1992). In many cases, it is the sensitized response that signals pathological consequences or acclimation to repeated exposure to a stressor (i.e., researchers look for sensitization to a novel stimulus to assess acclimation to a previous, repeated stimulus). It is important to recognize that apparently calm or other non-responsive behavior does not necessarily indicate acclimation (see Beale, this issue). In addition, acclimatizing to a stimulus (e.g., an intense sound source) may reduce the stress response, but not eliminate the potential physiological damage on, for instance, hearing. Examples of this have been seen in human behavior (see Clark & Stansfeld, this issue).

Working definitions

In light of the above, participants agreed to use the following terminology and definitions (based mostly from Romero, 2004) for the purpose of the workshop. This does not necessarily reflect the preferred usage for any individual, nor establish a position in any discussion surrounding the concepts.

Stressor: a threatening or unpredictable stimulus that causes a stress response.

Stress response: the physiological, hormonal and behavioral changes that result from exposure to a stressor.

Chronic stress: a state that an organism enters when repetitive or long-term exposure to a stressor has exceeded an organism's regulatory capacities.

Context of a stressor: the physical and psychological conditions present when a stressor appears.

Acclimation: after repeated or chronic exposure to a single stressor, an animal no longer perceives the stressor to be threatening and reduces its physiological stress response. The decrease in stress response is specific to that stressor and does not generalize to other stressors as long as the animal is capable of distinguishing between them.

Sensitization[2]: when acclimation to one stressor increases subsequent stress responses to novel stressors.

"Stress hormones": a generic and non-scientific term for hormones whose concentrations change in response to stressors and are indicative of a stress response. They are divided in two main types: catecholamines (e.g., epinephrine/adrenaline, norepinephrine/norarenaline, etc.) and glucocorticoid-steroid hormones (e.g., cortisol, corticosterone, etc.). Some hormones (e.g., cortisol) have been traditionally used as indicative of stress. However, they may exhaust under repetitive stimuli and may not reflect chronic stress.

Steroid hormones: a class of hormones (including testosterone, estradiol and cortisol) typified by a four-ring structure.

Acknowledgements

Many thanks are due to all the workshop participants; whose contributions in terms of time and energy have made this effort more productive than the organizers had dared to hope. In particular, thanks go Giuseppe Notarbartolo di Sciara, who rose admirably to the challenge of chairing this incredibly diverse workshop. The Co-Editors would also like to specifically thank, on behalf of themselves as well as all the workshop participants, Dieter Paulmann (founder of Dokumentes des Meeres), whose financial support, scientific curiosity and vision brought the participants together, and Jo Hastie, whose organizational skills brought the participants physically together. Thanks are also due to the staff at the Hesperia Lanzarote for all their help and patience during the workshop. And last, but by no means least, all the organizers and participants give their thanks to everyone at the Museo de Cetáceos de Canarias for their help in logistical organization and, perhaps most importantly, their friendship and hospitality.

[2] We use sensitization instead of facilitation as per Romero (2004) as this is the standard term in the psychological literature.

References

Bejder, L., Samuels, A., Whitehead, H., & Gales, N. (2006). Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. *Animal Behaviour*, **72**, 1149-1158.

Clark, C. & Stansfeld, S. (2007). Non-auditory effects of noise on human health: a review of recent evidence. *International Journal of Comparative Psychology*, **this issue**, 145-158.

Dallman, M. F., Akana, S. F., Scribner, K. A., Bradbury, M. J., Walker, C.-D., Strack, A. M. & Cascio, C. S. (1992). Stress, feedback and facilitation in the hypothalamo-pituitary-adrenal axis. *Journal of Neuroendocrinology*, **4**, 517-526.

Domjan, M. (2005). *The Essentials of Conditioning and Learning.* Thonson Wadsworth: Belmont, CA.

Fair, P. A. & Becker, P. R. (2000). Reviews of stress in marine mammals. *Journal of Aquatic Ecosystem Stress and Recovery*, **7**, 335-354.

Hatch, L. & Wright, A. J. (2007). A Brief Review of Anthropogenic Sound in the Oceans. *International Journal of Comparative Psychology*, **this issue**, 121-133.

Kuczaj, S.A. II & Xitco, M.J. (2002). It takes more than fish: the comparative psychology of marine mammal training. *International Journal of Comparative Psychology*, **15**, 186-200.

McEwen, B. S. & Wingfield, J. C. (2003). The concept of allostasis in biology and biomedicine. *Hormones & Behavior*, **43**(1), 2-15.

MMS, Alaska OCS Region – Minerals Management Service, Alaska OCS Region (2007). *Chukchi Sea Planning Area Oil and Gas Lease Sale 193 and Seismic-Surveying Activities in the Chukchi Sea. Final Environmental Impact Statement.* OCS EIS/EA MMS 2007-026. Anchorage, Alaska: U.S. Department of the Interior Minerals Management Service, Alaska OCS Region. vi + 617 pp + appendices. Available from: http://www.mms.gov/alaska/ref/EIS%20EA/Chukchi_feis_Sale193/feis_193.htm

Nowacek, D. P., Thorne, L. H., Johnston, D. W. & Tyack, P. L. (2007). Responses of cetaceans to anthropogenic noise. *Mammal Review*, **37**(2), 81-115.

NRC – U.S. National Research Council (2003). *Ocean Noise and Marine Mammals*. Washington, DC: National Academy Press. 204 pp.

NRC – U.S. National Research Council (2005) *Marine Mammal Populations and Ocean Noise: Determining When Noise Causes Biologically Significant Effects*. Washington, DC: National Academy Press. 126pp.

Richardson, W. J., Greene, C. R.,Malme, C. I. & Thomson, D. H. (1995). *Marine Mammals and Noise*. Academic Press, San Diego, CA. 576pp.

Romero, L. M. (2004). Physiological stress in ecology: Lessons from biomedical research. *Trends in ecology and evolution*, **19**, 249-255.

Telch, M. J., Valentiner, D. P., Ilai, D, Petruzzi, D., & Hehmsoth, M. (2000). The facilitative effects of heart-rate feedback in the emotional processing of claustrophobic fear. Behaviour Research and Therapy, **38**, 373-387.

Wright, A. J., Aguilar Soto, N., Baldwin, A. L., Bateson, M., Beale, C., Clark, C.et al. (2007a). Anthropogenic Noise and Physiological Stress: Behaviour, Context and Animal Welfare. *International Journal of Comparative Psychology*, **this issue**, 250-274.

Wright, A. J., Aguilar Soto, N., Baldwin, A. L., Bateson, M., Beale, C., Clark, C. et al. (2007b). Are Marine Mammals Stressed By Anthropogenic Noise? *International Journal of Comparative Psychology*, **this issue**, 274-316.

International Journal of Comparative Psychology, 2007, **20**, 89-95.
Copyright 2007 by the International Society for Comparative Psychology

Endocrinology of Stress

L. Michael Romero and Luke K. Butler
Tufts University, U. S. A.

When an animal detects a stressor, it initiates a stress response. The physiological aspects of this stress response are mediated through two endocrine systems. The catecholamine hormones epinephrine and norepinephrine are released from the adrenal medulla very rapidly and have numerous effects on behavior, metabolism, and the cardiovascular system. This is commonly termed the Fight-or-Flight response. On a longer time scale, the glucocorticoid hormones are released from the adrenal cortex. They interact with intracellular receptors and initiate gene transcription. This production of new proteins means that glucocorticoids have a delayed, but more sustained, effect than the catecholamines. The glucocorticoids orchestrate a wide array of responses to the stressor. They have direct effects on behavior, metabolism and energy trafficking, reproduction, growth, and the immune system. The sum total of these responses is designed to help the animal survive a short-term stressful stimulus. However, under conditions of long-term stress, the glucocorticoid-mediated effects become maladaptive and can lead to disease.

Stress, as originally coined by Selye (1946), has been the subject of study for decades. It became quickly apparent that the term "stress" actually encompasses three related topics: changes/stimuli from the environment that cause "stress" (subsequently called stressors); the physiological and psychological responses to those stimuli (subsequently called the stress response); and the diseases that result from an overstimulation of the physiological and psychological responses (subsequently called chronic stress effects). Research has focused on all three of these concepts. An enormous amount is now known about what stimuli elicit which physiological and psychological responses. We also know many of the mechanisms whereby various hormonal mediators compromise organ, tissue, and cellular function (Fink, 2007). This paper will provide a brief overview of what is known about the endocrine responses to stressors. The following general information is broadly known and widely presented. Most of the information comes from the following sources (McEwen & Goodman, 2001; Nelson, 2005; Norman & Litwack, 1997; Norris, 2007; Sapolsky, Romero, & Munck, 2000) and interested readers should consult them for more detail. Specific information and individual studies are cited independently.

Although there are many hormones that have been identified as playing a role in the vertebrate stress response, two categories of hormones are thought to form the central components of the endocrine response. These are the catecholamines, epinephrine and norepinephrine (also known as adrenalin and noradrenalin) and the glucocorticoids. Together, these hormones help to orchestrate the body's stress response. How they do so is presented below.

This work was supported by NSF grant IOB-0542099 to LMR. Correspondence concerning this article should be addressed to L. Michael Romero, Department of Biology, 163 Packard Ave, Tufts University, Medford, MA, 02155 U. S. A. (Michael.romero@tufts.edu).

Catecholamine Responses

The catecholamines are a class of hormones consisting of a 6-carbon ring with a carbon side chain. The type of side chain determines the type of catecholamine and provides biological specificity. The two most important catecholamines in the stress response are epinephrine (Epi) and norepinephrine (Norepi). The catecholamines bind to specific membrane-bound G-protein receptors. When bound, these receptors initiate an intracellular cAMP signaling pathway that rapidly activates cellular responses. The speed at which these responses are activated provides the foundation for many of the catecholamine effects.

The suite of responses mediated by Epi and Norepi are commonly called the Fight-or-Flight response because they have immediate effects on increasing the readiness and activity of the animal. Upon detection of a stressor, Epi and Norepi are released by both the adrenal medulla and nerve terminals of the sympathetic nervous system. These hormones are produced beforehand and stored in secretory vesicles. Consequently, release of Epi and Norepi occurs rapidly after detection of a stressor. When coupled to the rapid activation of cellular processes through their receptors in target tissues, Epi and Norepi activate organism-level responses within seconds of detecting a stressor.

Epi and Norepi activate a number of responses, including: decreasing visceral activity and shutting down digestion; increasing visual acuity; increasing brain blood flow and arousal; increasing gas exchange efficiency in the lungs; breaking down glycogen to release glucose stores; inducing vasodilation in muscles; inducing vasoconstriction in the periphery; increasing heart rate; and inducing piloerection. This suite of responses comprises the classic Fight-or-Flight response and is designed to help the animal survive an acute threat such as an attack by a predator or conspecific competitor. They not only activate beneficial responses such as increasing alertness and providing energy to muscles, but also inhibit processes, such as digestion, that can be superfluous during an acute emergency.

Glucocorticoid Responses

Glucocorticoids are a class of steroid hormones consisting of a 4-ring carbon backbone with different hydroxyl groups and carbon side chains attached at various places around the rings. The particular side chain and where it is attached determines which steroid it is, and provides specificity for the various steroid receptors. All steroids share common precursors and common synthetic pathways and are interconverted, so that both the classic steroid hormones (e.g., testosterone) and their intermediates (that can also have biological activity) can be found both in tissues and in the blood. However, the primary steroids released in response to a stressor are the glucocorticoids (GCs): cortisol and corticosterone. Most species rely primarily upon either cortisol (e.g. fish and most mammals, including humans and marine mammals) or corticosterone (e.g. birds, reptiles, amphibians, and some rodents), although both can be found in most species and some species rely upon a

mix of the two (e.g. some rodent species). Both hormones bind to the same receptors and appear to have identical functions in their respective species.

The release of GCs results from a hormonal cascade that begins with the detection of a stressor. Areas of the brain that interpret external and/or internal stimuli (e.g. the amygdala and hippocampus) send neuronal signals to the hypothalamus (primarily the paraventricular nucleus). The cells in the hypothalamus send axon projections to the median eminence where they terminate along capillaries of a portal blood system that connects to the anterior pituitary. Once stimulated, the hypothalamic cells release a suite of hormones into the portal blood. The most important of these hormones are corticotropin-releasing factor (CRF) and arginine vasopressin (AVP – or arginine vasotocin in non-mammalian vertebrates). (Although CRF is sometimes referred to as CRH (corticotropin releasing hormone), a recent committee addressing nomenclature proposed that CRF be adopted as the appropriate name (Hauger et al., 2003) CRF and AVP travel the short distance of the portal blood system from the base of the hypothalamus to the anterior pituitary. There they bind to receptors and stimulate the release of adrenocorticotropic hormone (ACTH). ACTH is then released into the general circulation and travels to the adrenal cortex where it binds to its receptors and stimulates the production of steroid synthetic enzymes. GCs, like all steroids, are not stored once they are produced, so there is no functional difference between ACTH-induced production of GCs, and the release of GCs into the bloodstream. Thus, the increase in production rate results in increased GCs released into the peripheral circulation. This hormonal cascade from the hypothalamus to the adrenal via the pituitary is called the Hypothalamic-Pituitary-Adrenal (HPA) axis. Although other factors, such as gonadal steroids, cytokines, and the splanchnic nerve, can also directly or indirectly modulate GC secretion, the HPA axis is the primary pathway stimulating GC release in response to a stressor.

Once released, GCs travel in the peripheral circulation primarily bound to corticosteroid binding globulins (CBG). Steroids are highly lypophilic so that most GCs are bound to CBG, but unbound GCs increase dramatically during a stress response. Whether CBG functions primarily as a carrier to deliver GCs to their target tissues, or primarily as a buffer to moderate GC function, is currently under debate (e.g. Breuner & Orchinik, 2002). Once at the target tissue, GCs pass through the outer cell membrane and bind to an intracellular cytoplasmic receptor. Activated receptors then enter the nucleus and begin acting as transcription factors. Activated receptors bind to short stretches of DNA sequences called glucocorticoid response elements and act as promoters or inhibitors of gene transcription. Consequently, the end product of GC stimulation is either the production of new proteins or the inhibition of protein production. In addition, there is evidence that a membrane-bound receptor for GCs exist. This receptor is believed to mediate rapid behavioral effects of GCs. Along with GC's effects in response to a stressor, GCs vary in a circadian rhythm and are important in regulating normal physiological processes.

In contrast to Epi and Norepi, GCs are much slower at exerting their effects. The multiple steps of the HPA axis ensure a time lag between the onset of a stressor and the increase in blood GC concentrations. In general, increases in GC

concentrations cannot be detected in under 3-5 min (and occasionally longer for some species). When coupled with GCs' primary effect of altering gene transcription rates, the physiological impact of GCs begins to occur approximately 20-30 min after the onset of a stressor. If a stressor does not continue, negative feedback will generally start to reduce GC concentrations in 30-60 min, although because the newly produced proteins can continue to function, GCs' physiological effects can last considerably longer. Consequently, the catecholamines and the GCs dovetail to produce both an immediate and a longer-term response to stressors.

Although GCs alter gene transcription rates for an enormous number of genes, at the organismal level GCs can be classified as having five broad effects (Romero, 2004): increasing blood glucose concentrations; altering behavior; inhibiting growth; inhibiting reproduction; and modulating the immune system. This suite of effects is believed to help the animal recover from a stressor, shut down those systems that can profitably be delayed until the danger has passed, and prepare the animal for potential subsequent stressors. Each of these broad effects will be discussed briefly below.

The classic effect of GCs is to increase the blood glucose available to tissues involved in responding to a stressor. In fact, the name "glucocorticoids" was assigned to these hormones because of this important role, which takes two general forms. First, GCs increase blood glucose by converting protein to glycogen, thereby indirectly increasing glycogen break down into glucose by Epi and Norepi, and by stimulating the catabolism of protein to form new glucose in a process called gluconeogenesis. Second, GCs reduce the uptake of blood glucose by target tissues, resulting in higher blood glucose concentrations available to tissues involved in responding to stress. GCs do this by stimulating the internalization of glucose transport molecules from the cell surface of target tissues. Fewer glucose transporters result in less glucose utilization, the sum of which across multiple target tissues results in higher blood glucose concentrations. Tissues that need extra glucose to respond to the stressor (e.g. muscles) compensate for the GC effect and essentially have preferential access to the increased pool of blood glucose. The sum of these effects is that GCs orchestrate the allocation of energy stores during either prolonged stressors or after stressors have ended (Dallman et al., 1993).

GCs are known to alter behavior, but how they alter behavior depends upon the context in which the stressor is presented. Specific behavioral changes are difficult to predict. Although there has been an enormous amount of research on GCs' behavioral effects in the laboratory, recent research has also included studies of wild animals in their native habitats. For example, studies have shown that GCs can induce migratory activity in birds (Silverin, 1997). Depending upon the environmental context, GCs can promote a behavioral strategy of hiding and waiting out a stressor, or promote a behavioral strategy of abandoning an area and fleeing the stressor (Wingfield & Ramenofsky, 1997). The mechanisms for how GCs alter behavior are currently unknown and an active area of research, but may involve a novel membrane-bound G-protein receptor that induces rapid behavioral

effects. GCs can also induce long-term behavioral changes by having a direct effect on memory formation and consolidation in the brain.

GCs inhibit growth by blocking the secretion of growth hormone from the pituitary, decreasing the sensitivity of target cells to growth hormone, and inhibiting protein synthesis (related to GC-stimulated gluconeogenesis from protein catabolism mentioned above) (Sapolsky, 1992). This is a transient effect during acute stress responses and, because growth is a long-term process, appears to have little impact on the overall growth of the animal. Prolonged exposure to GCs, however, can result in observable inhibition of growth. In humans, the syndrome is called psychosocial dwarfism (Green, Campbell, & David, 1984). Inhibition of growth is believed to be an example of GCs shifting resources away from processes that can be postponed in order to use those resources to cope with an emergency.

GCs also inhibit reproduction (Wingfield & Romero, 2001). Vertebrate reproduction is regulated with a hormonal cascade that is similar to the HPA axis. The hypothalamus releases gonadotropin releasing hormone (GnRH), which causes the pituitary to release leutenizing and follicle-stimulating hormones (LH and FSH), which in turn stimulate gamete formation and reproductive steroid production (e.g. testosterone and estradiol) by the gonads. GCs suppress this pathway in several ways: by inhibiting GnRH release, reducing pituitary sensitivity to GnRH, and reducing the sensitivity of gonads to LH. Furthermore, GCs can reorient behavior away from reproduction. Similar to the effects on growth, GCs' effects on reproduction have little impact over the short-term, but long-term stress can cause complete reproductive shutdown. Stress has even been implicated as a factor in human infertility (Homan., Davies, & Norman, 2007; Wischmann, 2003). GCs' effects on reproduction are thought to be another example of allocating resources preferentially during an emergency.

Interestingly, the reproductive system can become resistant to inhibition by GCs in some reproductive contexts. For example, if GCs allocate resources away from reproduction, and thereby reduce individual fitness (i.e. successful production of offspring), the benefit of the reproductive system ignoring the GC signal may outweigh the cost of not responding to the stressor. In semelparous species (those that breed once and then die) such as some salmon species and several Australian marsupial rodents, death occurs in all individuals (or all individuals of one sex) shortly after breeding. The proximate cause of death is extremely high levels of GCs that catabolize essential proteins (reviewed in Wingfield & Romero, 2001). Reproduction in these animals clearly continues despite elevated GCs. Furthermore, GCs do not inhibit reproduction in many short-lived species and in older individuals, and in dominant individuals in some species where the dominant individual has a limited period with access to mates (Wingfield & Sapolsky, 2003). Consequently, susceptibility to GC-induced inhibition of reproduction is highly specific depending on the importance of continuing to reproduce in the presence of stress which may vary depending upon age, sex, stage of the breeding cycle, etc.

Finally, GCs have a broad inhibitory effect on the immune system (Spencer, Kalman, & Dhabhar, 2001). This has made GCs very important clinically and they are widely prescribed as drugs. GCs have a number of effects

on the immune system including: inhibiting the synthesis, release, and efficacy of cytokines (immune system proteins); inhibiting antigen presentation through reduced major histocompatibility complex (MHC) expression; reducing the activation and proliferation of T cells, B cells, and macrophages; lowering the circulating levels of lymphocytes; reducing lymphocyte chemotaxis; reducing the number of phagocytic cells at inflammation sites; stimulating atrophy of the thymus; and triggering the death of immature T and B cells. All of these effects lead to immunosuppression, especially with long-term GC exposure. There is some evidence, however, that GCs might enhance immune function in the short-term (Dhabhar, 2006; Dhabhar & McEwen, 1999). The reason GCs have such powerful immunosuppressive effects is not entirely clear, but it has been proposed as a mechanism to prevent overactivation of the immune system that could lead to autoimmune diseases.

Conclusion

The large suite of catecholamine and GC responses is believed to be essential in surviving stressors. Clearly, the lack of Epi and Norepi release, i.e. the Fight-or-Flight response, would be devastating during a predatory attack. Similarly, animals that lack GCs are unable to mount an effective stress response and quickly die (Darlington, Chew, Ha, Keil, & Dallman, 1990). All three hormones serve to orchestrate an organism's effective response to stressors in order to promote survival.

On the other hand, long-term or chronic release of these hormones can be detrimental. Repeated or constant activation of the Fight-or-Flight response can lead to cardiovascular disease. Similarly, individuals exposed to long-term or chronic GCs suffer from a number of diseases including diabetes, depression, psychosocial dwarfism, reproductive dysfunction, and immune suppression. Consequently, responses to acute stressors generally enhance fitness, but long-term exposure can decrease fitness. Clearly, successful long-term survival requires balancing acute release while minimizing chronic exposure.

References

Breuner, C. W., & Orchinik, M. (2002). Beyond carrier proteins: Plasma binding proteins as mediators of corticosteroid action in vertebrates. *Journal of Endocrinology,* **175**, 99-112.

Dallman, M. F., Strack, A. M., Akana, S. F., Bradbury, M. J., Hanson, E. S., Scribner, K. A., Smith, M. (1993). Feast and famine: Critical role of glucocorticoids with insulin in daily energy flow. *Frontiers of Neuroendocrinology,* **14**, 303-347.

Darlington, D. N., Chew, G., Ha, T., Keil, L. C., & Dallman, M. F. (1990). Corticosterone, but not glucose, treatment enables fasted adrenalectomized rats to survive moderate hemorrhage. *Endocrinology,* **127**, 766-772.

Dhabhar, F. S. (2006). Stress-induced changes in immune cell distribution and trafficking: Implications for immunoprotection versus immunopathology. In *Neural and neuroendocrine mechanisms in host defense and autoimmunity* (pp. 7-25).

Dhabhar, F. S., & McEwen, B. S. (1999). Enhancing versus suppressive effects of stress hormones on skin immune function. *Proceedings of the National Academy of Sciences of the United States of America,* **96**(3), 1059-1064.

Fink, G. (Ed.). (2007). *Encyclopedia of stress, second edition.* Oxford: Academic Press.

Green, W. H., Campbell, M., & David, R. (1984). Psychosocial dwarfism: A critical review of the evidence. *J Am Acad Child Psychiatry,* **23**(1).

Hauger, R. L., Grigoriadis, D. E., Dallman, M. F., Plotsky, P. M., Vale, W. W., & Dautzenberg, F. M. (2003). International union of pharmacology. Xxxvi. Current status of the nomenclature for receptors for corticotropin-releasing factor and their ligands. *Pharmacological Reviews,* **55**(1), 21-26.

Homan, G. F., Davies, M., & Norman, R. (2007). The impact of lifestyle factors on reproductive performance in the general population and those undergoing infertility treatment: A review. *Human Reproduction Update,* **13**(3), 209-223.

McEwen, B. S., & Goodman, H. M. (Eds.). (2001). *Handbook of physiology; section 7: The endocrine system; volume IV: Coping with the environment: Neural and endocrine mechanisms.* New York: Oxford University Press.

Nelson, R. J. (2005). *An introduction to behavioral endocrinology* (3 ed.). Sunderland, MA: Sinauer Associates.

Norman, A. W., & Litwack, G. (1997). *Hormones* (2 ed.). Boston: Academic Press.

Norris, D. O. (2007). *Vertebrate endocrinology* (4 ed.). Boston: Academic Press.

Romero, L. M. (2004). Physiological stress in ecology: Lessons from biomedical research. *Trends in ecology and evolution,* **19**, 249-255.

Sapolsky, R. M. (1992). *Stress, the aging brain, and the mechanisms of neuron death.* Cambridge, MA: MIT Press.

Sapolsky, R. M., Romero, L. M., & Munck, A. U. (2000). How do glucocorticoids influence stress-responses? Integrating permissive, suppressive, stimulatory, and adaptive actions. *Endocrine Reviews,* **21**, 55-89.

Selye, H. (1946). The general adaptation syndrome and the diseases of adaptation. *Journal of Clinical Endocrinology,* **6**, 117-230.

Silverin, B. (1997). The stress response and autumn dispersal behaviour in willow tits. *Animal Behaviour,* **53**(3), 451-459.

Spencer, R. L., Kalman, B. A., & Dhabhar, F. S. (2001). Role of endogenous glucocorticoids in immune system function: Regulation and counterregulation. In B. McEwen & H. M. Goodman (Eds.), *Handbook of physiology; section 7: The endocrine system; volume IV: Coping with the environment: Neural and endocrine mechanisms.* (pp. 381-423). New York: Oxford University Press.

Wingfield, J. C., & Sapolsky, R. M. (2003). Reproduction and resistance to stress: When and how. *Journal of Neuroendocrinology,* **15**(8), 711.

Wingfield, J. C., & Romero, L. M. (2001). Adrenocortical responses to stress and their modulation in free-living vertebrates. In B. S. McEwen & H. M. Goodman (Eds.), *Handbook of physiology; section 7: The endocrine system; volume IV: Coping with the environment: Neural and endocrine mechanisms.* (pp. 211-234). New York: Oxford Univ. Press.

Wingfield, J. C., & Ramenofsky, M. (1997). Corticosterone and facultative dispersal in response to unpredictable events. *Ardea,* **85**, 155-166.

Wischmann, T. H. (2003). Psychogenic infertility: Myths and facts. *Journal of Assisted Reproduction and Genetics,* **20**(12), 485-494.

International Journal of Comparative Psychology, 2007, **20**, 96-110.
Copyright 2007 by the International Society for Comparative Psychology

From Classic Aspects of the Stress Response to Neuroinflammation and Sickness: Implications for Individuals and Offspring

Terrence Deak
State University of New York at Binghamton, U.S.A.

Accumulating evidence suggests that exposure to psychological stressors leads to increased expression of pro-inflammatory cytokines and activation of inflammatory-related pathways in the central nervous system. Several logical predictions arise from these findings: (1) stressor exposure should produce changes in behavior that are reminiscent of acute illness; (2) administration of anti-inflammatory agents should ameliorate some behavioral consequences of stressor exposure; and (3) there should be convergence between anatomical and neurochemical pathways activated by stressor exposure and those involved in mitigating sickness behaviors. Importantly, these predictions have been tested in our laboratory across multiple stressor paradigms (footshock, maternal separation, and during acute alcohol withdrawal) using two species (rats and guinea pigs), suggesting that sickness may represent a more general motivational state that can be elicited by a diverse range of psychological challenges. Implications of these findings for understanding stress-related changes in behavior, mood and neuroinflammatory processes will be discussed with special reference to implications for the individual and reproductive fitness.

The concept of stress has suffered a long and contentious history with little agreement even today about what it entails (e.g., McEwen & Wingfield, 2003). The problem becomes particularly apparent when one tries to operationalize the term for scientific study, and even worse when one seeks to determine the impact of stress on individuals or populations. In its crudest form, the concept of stress can be broken down into three principle components which I will describe in some detail below, using what is known about central nervous system (CNS) regulation of the stress response as a lens through which consequences of stressor exposure might be viewed. The first component must be the evocative agent: the general construct of stress can be parsed into categorically distinct threats (often termed stressors), each of which may activate the major stress responsive systems to varying degrees. The *stress response*, therefore, becomes the second principle component and refers to the constellation of changes (behavioral, physiological, or psychological) provoked by the actual or perceived threat. Finally, the impact of stress exposure on the overall health of the organism (Component III) must in some way be a function of the stress response(s) that have been evoked by the stressor. As a result, stress-responsive systems have been studied extensively in biomedical research as core systems that mediate and/or modulate nearly all disease-related processes (whether infectious, traumatic or genetic in nature). Ecologists, on the other hand, are particularly interested in the impact of anthropogenic stressors on the welfare and reproductive fitness of diverse species. With that in mind, the goal

This work was supported by grants from the National Science Foundation (NSF grant number 0549987) and the Hope for Depression Research Foundation (HDRF grant number 6-008). Any opinions, findings, conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the above stated funding agencies. Correspondence concerning this article should be addressed to Terrence Deak, Department of Psychology, SUNY-Binghamton, Vestal Parkway East, Binghamton, NY, 13902-6000, U.S.A. (tdeak@binghamton.edu).

of the following review is to help bridge the gap between these seemingly disparate fields.

The Classic Stress Responsive Systems

Two classic systems that are principally activated during times of stress are the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenal (HPA) axis. Though they will be discussed categorically below, it is in fact the combined effort of the SNS and HPA axis – among other critical endocrine and neural systems – that ultimately comprise an organism's response to stress. These systems are activated rapidly in response to stressful stimuli and have a broad impact on diverse aspects of physiological functioning. Indeed, many of the delayed and/or long-term consequences of stressor exposure are set into motion as a downstream consequence of the initial SNS and HPA responses. In this regard, indirect measures of SNS activation (such as increased heart rate, blood pressure, or hyperthermia) or direct measures of SNS output (plasma concentrations of epinephrine and norepinephrine) and HPA activation (corticosteroid concentrations in plasma, tissue or excrement) are often used as an index for the severity of a stressor that has been encountered. Regardless of which measure is examined, the magnitude of the stress response is best defined as 'area under the curve' whenever possible because this measure integrates peak response with duration of stressor exposure (Barnum, Blandino Jr, & Deak, 2008; Pacak & Palkovits, 2001). Note, however, that for these measures to be useful indices of the stress response, they must be (a) assessed with respect to a known baseline or non-stressed condition in the same animal or a group of conspecifics that have been otherwise treated identically; (b) evaluated in a threatening context, since pleasurable experiences such as sexual intercourse (Bonilla-Jaime, Vazquez-Palacios, Arteaga-Silva, & Retana-Marquez, 2006), euphoria produced by drugs of abuse (Goeders & Clampitt, 2002), or anticipation of palatable food (Pecoraro, Gomez, Laugero, & Dallman, 2002) also elicit profound activation of these same physiological response systems but do not fit the intuitive mold of 'stress'; and (c) considered within the context of circadian rhythms, as corticosteroids and catecholamines both evince diurnal variation. Some caution is therefore prudent in the interpretation of physiological measures that are used to infer that a given response is a manifestation of stress.

The sympathetic nervous system is a fast-acting response to stress that can be detected within seconds of stressor onset, assuming that the onset is a punctate event (i.e., one with a clearly defined beginning and end, such as detection of a predatorial attack). In other cases, SNS activation is often described as a steadily escalating 'tone', where over the course of hours, days or months (depending on the nature of the stressor), general activity of the SNS is increased, leading to increased metabolic demand and gradual wear-and-tear on physiological systems (allostatic load) that may eventually culminate into physiological failures (allostatic overload) (McEwen & Wingfield, 2003).

Mechanistically, the vital nature of SNS responses to stress is underwritten by the redundancy evident in the system. For instance, SNS activation leads to the release of the catecholamines epinephrine and norepinephrine from sympathetic

nerve terminals that innervate all organs of the body and the musculature, allowing for rapid and profound changes in whole organism physiology. Epinephrine and norepinephrine are also released from the adrenal medulla into the general circulation where it acts as an endocrine signal (i.e., affecting distal targets) that helps prolong the action of neurally-derived catecholamines. These peripheral cascades of catecholamines are regulated by autonomic structures in the CNS such as the locus ceruleus (LC), nucleus of the solitary tract (NTS), the ventrolateral medulla (VLM) and the medial amygdala. Importantly, these structures all communicate to other structures in the CNS using predominantly (though not exclusively) norepinephrine and epinephrine, and are sensitive to internal homeostatic threats (hypoxia, hypoglycemia, immune stimuli, toxin and toxicant exposure, etc). These structures (particularly the LC) receive extensive input from brain structures involved in threat perception from the forebrain, thereby regulating peripheral sympathetic outflow through descending projections that activate sympathetic chain ganglia (see Guyton & Hall, 2006) for a general overview of SNS organization and function). Together, the redundant release of catecholamines directly onto target tissues from sympathetic nerve terminals, into the general circulation and locally within the CNS produces a coordinated, whole body response to stressful stimuli.

Though activation of the hypothalamic pituitary-adrenal (HPA) axis is somewhat slower to develop (usually within 3-5 min of stressor onset), the impact of corticosteroid release from the adrenal cortex is equally profound, though on a somewhat more protracted timeline. Every nucleated cell in the body expresses corticosteroid receptors, though the relative expression of these receptors differs markedly across cell and tissue types (Spencer, Young, Choo, & McEwen, 1990) and ultimately determines organ sensitivity to corticosteroids. Corticosteroids (cortisol in humans, corticosterone in rats) are the ultimate effector of the HPA response and are the end-product of a series of hormonal secretions that are initiated by cells in the paraventricular nucleus (PVN) of the hypothalamus (Dallman et al., 1987). As a result, the hypothalamus generally, and the PVN more explicitly, receives neural input from numerous other nuclei in the CNS involved in the perception of threat (i.e., stress) and is therefore uniquely situated as a final site of integration for the stress response. From a teleological perspective, this allows diverse threats to the organism (i.e., stressors) to activate a single effector response (corticosteroid release). The stereotyped release of corticosteroids in response to diverse stressors leads to mobilization of glucose from the liver, alterations in gene expression patterns and changes in cellular metabolic activity among other far-reaching consequences, all of which ultimately promote survival in the face of diverse threats (Munck, Guyre, & Holbrook, 1984).

Sickness and Neuroinflammation as a Consequence of Stress

While SNS and HPA responses to stress occur rather quickly, these responses inandof themselves do not readily explain the diverse range of long-term consequences of stress. For instance, exposure to relatively intense stress in rodents leads to reduced food and water consumption (Deak et al., 1999a; Dess, Raizer, Chapman, & Garcia, 1988; Marti, Marti, & Armario, 1994), decreased so-

cial and sexual behavior (Retana-Marquez, Salazar, & Velazquez-Moctezuma, 1996; Short & Maier, 1993; Uphouse, Selvamani, Lincoln, Morales, & Comeaux, 2005), and reduced activity/exploration in a novel environment (Woodmansee, Silbert, & Maier, 1993). Because these changes often persist for several days following stressor termination, they cannot be explained readily at a mechanistic level by activation of the principle stress responsive systems, the SNS and HPA axis, because these responses have largely resolved by the time the behavioral adaptations emerge. It is therefore advantageous to examine physiological and behavioral processes that occur in a protracted fashion following termination of the prototypical stress responses, and these effects will be the subject of the following discussion.

When this constellation of behavioral changes is viewed from the perspective of motivation rather than as individual behavioral changes, the overall pattern of changes seems to suggest decreased propensity to engage in goal-directed behavior. For many years, the biomedical research community has likened these changes to depressive-like tendencies (Gronli et al., 2005). While this interpretation provides clarity on clinical implications of intense stressor exposure, it does little to advance our understanding of brain mechanisms underlying such widespread consequences of stress. Moreover, this interpretation would seem to violate the implicit evolutionary presumption that the stress response – and behavioral consequences that ensue – somehow act in an *adaptive* manner to promote survival.

In light of this, we prefer to view the constellation of behavioral changes observed after stressor exposure as *recuperative responses* rather than pathological ones. In doing so, it becomes immediately apparent that the collective changes in behavior observed after intense stressor exposure are strikingly similar to those observed during acute illness produced by infection, termed sickness behaviors (Hart, 1988; Kent, Bluthe, Kelley, & Dantzer, 1992a). In fact the similarities between consequences of stressor exposure and acute illness extend well beyond behavioral changes and include alterations in neurotransmitter release (A.J. Dunn & Welch, 1991), changes in cognitive function (Gibertini, Newton, Friedman, & Klein, 1995; Pugh et al., 1999), as well as changes in peripheral immune function (see Maier & Watkins, 1998 for a review). These similarities led us to propose that many behavioral consequences of stressor exposure – particularly ones indicative of a general malaise – may be aptly described as 'stress-induced sickness behaviors' (Hennessy, Deak, & Schiml-Webb, 2001). This hypothesis arose from numerous empirical findings. First of all, stress can increase the expression of pro-inflammatory cytokines in the CNS (Deak et al., 2005b; Nguyen et al., 1998), and these factors are also known to be critical for the generation of sickness behaviors precipitated by acute illness (Bluthe et al., 1999; Kent, Bluthe, Kelley, & Dantzer, 1992a; Kent et al., 1992b). Injection of lipopolysaccharide (a component of cell walls of gram negative bacteria that is often used to mimic infection) or direct administration of pro-inflammatory cytokines provokes a similar complement of behavioral changes as intense stressor exposure (Hennessy et al., 2004; Plata-Salaman & French-Mullen, 1992). Acute stress also increases expression of acute phase proteins and evokes a sustained increase in core body temperature, effects

that can persist for days following stressor termination (Deak et al., 1997). Indeed, exposure to psychological stressors produces a fever response that is commonly used as a rapid and sensitive index of SNS activation (Barnum, Blandino Jr, & Deak, 2007; Oka, Oka, & Hori, 2001). Finally, and perhaps most compelling, central administration of anti-inflammatory agents can reverse many sickness-like changes provoked by stress (Hennessy et al., 2007; Milligan et al., 1998; Schiml-Webb, Deak, Greenlee, Maken, & Hennessy, 2005). Together, these data support the view that acute illness and stressor exposure produce many similar sequelae that are coordinated through common biological pathways.

In this regard, it is interesting to note that sickness responses to infection are thought to reflect a goal-directed process (i.e., a motivational state) designed to promote recuperation, not a debilitated state for the animal (Aubert, 1999; Dantzer, 2004; Hart, 1988). Evidence to support this hypothesis comes from the simple observation that sickness behaviors are more readily observed in the home cage environment of laboratory animals (i.e., a safe haven) than in a novel environment where threats are unknown. In a very clever study, it was shown that sick dams fail to rebuild their nest and retrieve pups at normal ambient temperatures, but readily do so in a cold environment that threatens her offspring (Aubert, Goodall, Dantzer, & Gheusi, 1997). Data from our own laboratory suggest that rats exhibit normal swim behavior while sick after doses of LPS that evoke a pronounced fever and increased cytokines that persist for 2-3 days (Deak, Bellamy, & Bordner, 2005a; Deak et al., 2005c). Such plasticity of behavior during times of immunological threat supports the view that sickness itself is a goal-directed, recuperative response. Our central argument, therefore, is that intense stressor exposure is followed by a similar recuperative period, mediated by common neural mechanisms.

Mechanistically, increased expression of pro-inflammatory cytokines in the CNS is likely to be the common biological mechanism that unites the consequences of stressor exposure and acute illness (Maier & Watkins, 1998). Of the many inflammatory factors that have been identified, Interleukin-1 (IL-1) appears to be particularly inducible by stress and the hypothalamus is a key structure where such changes are prevalent (Deak et al., 2005b). It is important to note, however, that not all stressors increase expression of IL-1 in the CNS. For instance, exposure of rats to simple restraint in a Plexiglas tube, brief social defeat or insulin-induced hypoglycemia had no effect on hypothalamic IL-1, while exposure to footshock, tailshock or immobilization all elicit profound increases in hypothalamic IL-1 (Deak, Bellamy, & D'Agostino, 2003; Nguyen et al., 1998; Plata-Salaman et al., 2000; Shintani, Nakaki, Kanba, Kato, & Asai, 1995). Interestingly, if simple restraint was administered in combination with a hypoglycemic challenge or on an orbital shaker, two procedures that change both the nature and intensity of the restraint experience, then increased hypothalamic IL-1 was in fact observed (Deak et al., 2005b). To the extent that increased IL-1 can be used to more broadly infer neuroinflammation, there are several potential explanations for these findings. First of all, there may be an *identifiable threshold* of stress that is necessary to provoke a neuroinflammatory response. Though stressor intensity is a notoriously difficult construct to define operationally, stressor intensity is often inferred based on the magnitude of the corticosteroid response observed (eg. Pace et al., 2005). In this

regard, it is noteworthy to mention that increased hypothalamic IL-1 and plasma corticosterone concentrations bare little association if any (Barnum et al., 2008; Deak et al., 2005b).

Figure 1. Venn diagrams categorizing the most commonly used stressor paradigms. Available data supports the view that most threats to mammalian species can be separated into at least two separate categories, described here as "physiological" and "psychological" stressors. Note, however, that some stressors are not readily classified into either category because the response they produce is significantly more profound than for other, more categorically distinct, stressors. To account for this, we use the term "compound stressors" to refer to stressors which fall in the overlapping portions of the Venn Diagram.

An alternative explanation for the apparent stressor-specific increases in hypothalamic IL-1 is that features of the stressors themselves are recognized in a categorically distinct fashion by the CNS and that only specific categories of stressors can activate a neuroinflammatory response. Indeed, there is general agreement among stress researchers that threats can be divided into at least two distinct categories based on the brain systems they activate (Dayas, Buller, Crane, Xu, & Day, 2001; Herman, Prewitt, & Cullinan, 1996; Sawchenko et al., 1996; Sawchenko, Li, & Ericsson, 2000). 'Psychological' stressors (also referred to as emotional, processive and neurogenic) are detected by the cognitive or perceptual apparatus of the organism and include paradigms such as restraint, novelty and predator exposure among others (see Figure 1). These stressors seem to preferentially activate forebrain and limbic structures such as the amygdala, prefrontal cortex, and hippocampus that send descending and/or lateral inputs to the PVN, thereby leading to activation of the HPA axis. 'Physiological' stressors (also referred to as physical, homeostatic or systemic), on the other hand, represent dire threats to organismic

functioning. As such, physiological stress encompasses internal threats to homeostasis such as hypoglycemia, hypoxia, hemorrhage, and immune challenge. These threats are detected largely by vital regulatory centers in brainstem autonomic nuclei including the VLM and NTS. These structures provide direct noradrenergic drive to the PVN through ascending fiber tracts, thereby leading to activation of the HPA axis (Herman & Cullinan, 1997).

Interestingly, some stressors yield brain activation patterns that do not fit neatly into the psychological or physiological categories, but instead seem to uniquely activate both sets of brain structures (Dayas et al., 2001). In this regard, if emotional and physiological stressors are opposite ends of the spectrum, then some stressors may lie more centrally because they uniquely comprise characteristics of both poles. This premise is depicted in Figure 1 where Venn diagrams are used to provide an overview of the numerous stressors employed in the laboratory setting. Note that direct empirical data is not available for all of these stressors, so stressors were arranged based on intuitive similarity to other stressors and/or the common outcomes produced by them.

To the extent that stressor intensity may be reflected by activation of quantitatively greater numbers of stress-responsive brain structures, stressors that fall in the central domain (termed 'compound stressors') would be expected to produce the most severe outcomes. From a functional neuroanatomical perspective, this would be reflected by a 'compound' drive to hypothalamic structures (particularly the PVN) because drive to the PVN would arrive from brainstem structures as well as forebrain/limbic structures. It is under these circumstances that activation of a neuroinflammatory response – indicated by increased expression of IL-1 and possibly other cytokines – is most likely to occur. Initial support for this hypothesis comes from our recent work showing that exposure to restraint in combination with a hypoglycemic challenge increased IL-1 in the hypothalamus, while neither stressor alone had any effect (Deak et al., 2005b). Whether this is due to activation of both psychological (restraint) and physiological (insulin-induced hypoglycemia) stress circuits or is a synergistic response produced by direct metabolic challenge to hypothalamic neurons (produced by insulin) during an otherwise mild stressor (restraint) remains to be determined. Regardless, the dual nature of the threat led to tell-tale signs of neuroinflammation, underscoring the potential impact for individuals when faced with multiple threats (i.e., stressors) that, if encountered individually, would otherwise have little consequence. In fact, it is likely to be the synergistic interaction among diverse threats – rather than the additive or cumulative ones – that are conceptually difficult to predict, yet represent the most profound threats to the health and vitality of all species.

The next logical question becomes, How do you get from the immediate perception of threat and activation of classic stress responsive systems (SNS and HPA axis) to neuroinflammation and a sickness-like syndrome? This question becomes particularly puzzling when one considers the prominent role of corticosteroids as counter-regulators of immune processes. That is, corticosteroids are widely known for their ability to inhibit inflammatory processes and are used clinically as a therapeutic tool to rapidly supplant inflammatory processes (Munck et al., 1984). However, the doses necessary to produce anti-inflammatory effects are typically

supraphysiological and there are numerous reports indicating that corticosteroids are necessary for normal progression of the immune response (Fleshner, Deak, Nguyen, Watkins, & Maier, 2002) and that lower doses of corticosteroids activate signal transduction pathways that promote inflammatory-gene expression. Indeed, there is compelling evidence that actions of corticosteroids (i.e, whether the effects are pro- or anti-inflammatory in nature) depend heavily on the tissue/cell types to which they bind (Sorrells & Sapolsky, 2007). With that said, removal of endogenous corticosteroids via adrenalectomy dramatically increases expression of IL-1 in the CNS provoked by stress (Nguyen et al., 1998; Nguyen et al., 2000), suggesting that corticosteroids constrain the development of neuroinflammation in response to stress. In contrast, the release of norepinephrine in both central nervous system structures and peripheral immune organs has been shown to increase the expression of proinflammatory cytokines (Blandino Jr, Barnum, & Deak, 2006; Johnson et al., 2005). Together, these findings suggest that neuroinflammatory consequences of stress may be mechanistically intertwined between the stimulatory actions of the SNS and the inhibitory influence of the HPA axis, though much work clearly remains to be done.

The Broader Impact of Stress-Related Neuroinflammation for Evolution and Ecology

Though the framework provided here focuses rather selectively on the ability of stress to increase pro-inflammatory cytokines in the CNS and its relationship to stress-induced sickness behaviors, the impact of cytokines and neuroinflammation extends well beyond an acute behavioral syndrome (summarized in Figure 2). Indeed, there are numerous laboratories examining the impact of neuroinflammation on cognitive function, mood, and affective disorders as well (Deak, 2007; Dunn, Swiergiel, & de Beaurepaire, 2005). From an evolutionary standpoint, these effects can be viewed as proximate consequences of stress insofar as they produce a readily observable and immediate impact on functioning of the individual. However, there is a broader cost to the individual that may not be immediately apparent and it is these costs that are most difficult to quantify. Because these costs are still for the affected individual (not offspring), I would suggest use of the term ‘distal consequences’ to describe them. For instance, normal aging of the CNS across the lifespan is associated with a transition to a greater pro-inflammatory cytokine balance, an effect that may be accelerated by repeated stressor exposure (Frank et al., 2006). Similarly, neuroinflammation is causally related to the development of neurodegenerative disorders such as Alzheimers Disease and Parkinson’s disease and may account for the earlier age of onset and worsening of symptoms produced by stress (eg. Whitton, 2007). Finally, our discussion has centered largely around neuroinflammation, but it is important to recognize that many of the same inflammatory-related changes are observed in other systems as well. As such, activation of inflammatory-related pathways during times of stress has been associated with the development and/or exacerbation of cardiovascular disease (Black, 2002), rheumatoid arthritis and Crohn’s Disease, as well as autoimmune disorders such as multiple sclerosis, lupus and Type I Di-

abetes. Perhaps even worse, increased IL-1 in the CNS sensitizes later stress reactivity that can be observed days to weeks later (Deak, Bellamy, & Bordner, 2005a; Johnson et al., 2002; Schmidt, Aguilera, Binnekade, & Tilders, 2003), suggesting that the impact of chronic stress across the lifespan may feed-forward into progressively more deleterious stress consequences. To this end, activation of inflammatory pathways in the CNS may more generally portend the erosion of individual health. From an ecological perspective, this would be more likely manifest as reduced longevity (due to greater susceptibility to predation) rather than full-blown disease states.

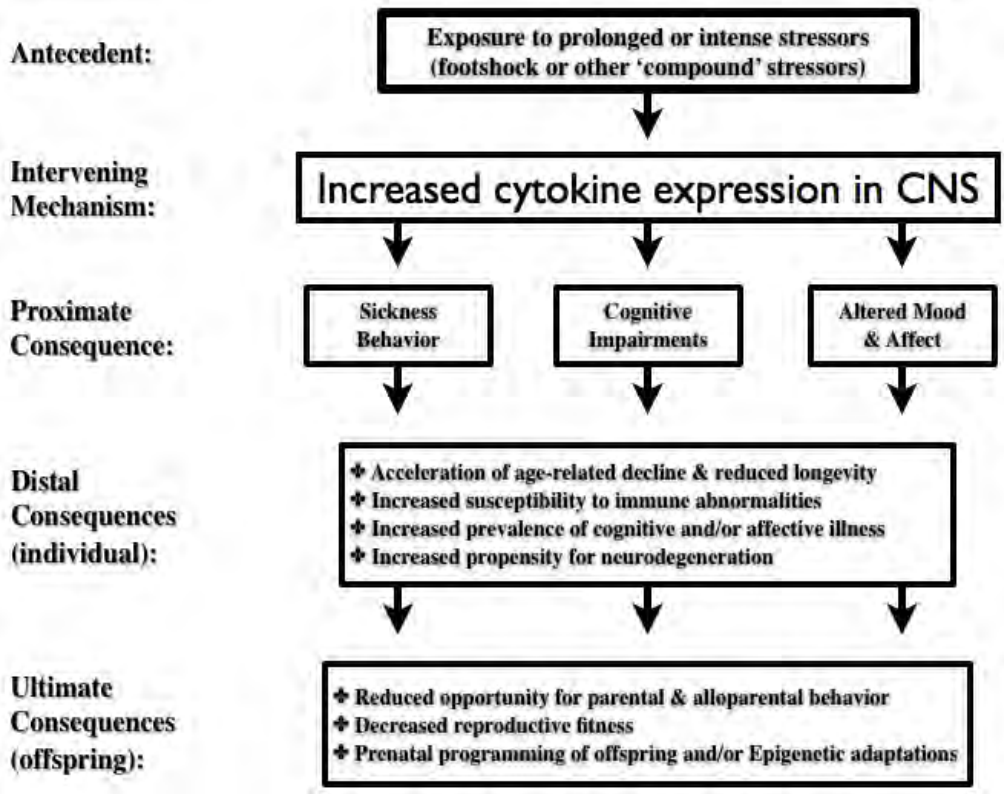


Figure 2. Schematic summary of central cytokine involvement in proximate, distal and ultimate consequences of stressor exposure.

The intrinsic or extrinsic factors that lead an individual to develop a given pathology in response to stress is not currently known in most cases. However, much the same as the ecologist is accustomed to thinking about speciation being driven by the various pressures of natural selection, the same principles may be turned inwardly towards the physiology of the individual. That is, we each possess a diverse range of organs and tissues that operate at some level of efficacy. The weakest of these organs or tissues – perhaps as a result of prior insult, developmental programming, or genetic liability – would be expected to show greater deterioration, wear-and-tear, or overt disease as a result of stress, thereby manifesting as

individual differences in stress reactivity. In the end, the disease states provoked or exacerbated by stressor exposure will undoubtedly enhance susceptibility to predation in the wild.

The impact of stress is not restricted to the individual and often extends to one's offspring as well. Such 'ultimate consequences' come in the straight-forward sense that reproductive behavior is often diminished during peak periods of stress, an effect that is also observed during acute illness, particularly for females (Avitsur & Yirmiya, 1999). Poor health associated with accelerated aging may reduce the opportunity for parental and alloparental behavior, thereby reducing social transmission of critical knowledge and skills later in life. Some of the most profound effects of stress on offspring occur by altering maternal behavior. Rat dams that spend more time licking and grooming their offspring yield litters that are more resilient to stress later in life, while maternal deprivation/neglect produces the opposite effects (Kaffman & Meaney, 2007). Similar effects have been observed in non-human primates where the amount of time the mother spends foraging predicts stress reactivity and mental health of her offspring, presumably because conditions where food is scarce or difficult to acquire lead to greater neglect of offspring (Gorman, Mathew, & Coplan, 2002; Rosenblum & Paully, 1984). As such, the impact of escalating foraging demand would be expected to have a particularly adverse impact on mammalian species where parental investment is high.

With that said, we must resist the call to view stress, stress responses or the consequences of stress in a purely deleterious manner. Recall instead that the principle stress responses (SNS and HPA axis) in addition to the inflammatory response have been highly conserved across the course of evolutionary history and therefore must provide significant adaptive benefit towards survival. For instance, exposure to acute stress has been shown to improve several aspects of wound healing and immune function, while chronic exposure to stressors can produce immunosuppressive effects (Deak et al., 1999b; Dhabhar & McEwen, 1997). These findings challenge the prevalent dogma that stress has only deleterious effects on immune function and remind us that the stress response has many adaptive qualities.

Insight into the adaptive nature of the stress response can also be gleaned by examining the evolution of the endocrine and inflammatory systems more generally. Modern evolutionary views argue that endocrine systems such as the HPA axis evolved initially from unicellular organisms where they were expressed as intracellular signaling cascades, which evolved into cell-to-cell signaling pathways in multicellular organisms, and so forth (Roth et al., 1985). Evidence for high affinity corticosteroid receptors in yeast cells (*Candida albacans*) suggests that rudimentary "HPA axes" may have followed a similar evolutionary path (Malloy, Zhao, Madani, & Feldman, 1993). Though it has not been stated explicitly, the elements of neuroinflammation discussed here are all considered to be part of the 'innate' immune response, which is phylogenetically the most ancient component of the vertebrate immune system. This evolutionary framework suggests that activation of inflammatory pathways by stress is likely to generalize across taxonomic orders, though clearly more work is necessary to test this hypothesis. Based on available data, however, it is reasonable to conclude that stress-related neuroinflammation and the sickness-like cascade that ensues must also have some adap-

tive value. To my mind, it makes good evolutionary sense that the magnitude of the recuperative response provoked by stress should somehow vary as a function of stressor intensity. Whether 'stressor intensity' in this case more aptly refers to crossing some identifiable threshold or is defined by unique features of the stress experience itself remains to be determined. Regardless, it is clear that hallmark signs of neuroinflammation can be provoked by the assembly of two threats that individually are without influence on neuroinflammation, as when hypoglycemia was combined with restraint as a unitary challenge (Deak et al., 2005b). In this regard, one might speculate that exposure to threats such as low-level toxin or toxicants from the environment might interact synergistically with, or lower the threshold for, otherwise innocuous threats (brief capture, increased foraging demand, anthropogenic noise, etc) to produce more severe consequences for the individual than would otherwise be expected from isolated threats alone. But in the end, the principles of evolution remind us once again that conservation of biological function is as prevalent as niche adaptation. It is perhaps not so surprising, therefore, that surviving a threat of significant proportion requires a period of recuperation, and that natural selection has favored a unified biological approach (i.e., sickness) as the prevailing mechanism to promote recovery.

References

Aubert, A. (1999). Sickness and behaviour in animals: A motivational perspective. *Neuroscience and biobehavioral reviews,* **23**, 1029-1036.

Aubert, A., Goodall, G., Dantzer, R., & Gheusi, G. (1997). Differential effects of lipopolysaccharide on pup retrieving and nest beuilding in lactating mice. *Brain, Behavior & Immunity,* **11**, 107-118.

Avitsur, R., & Yirmiya, R. (1999). The immunobiology of sexual behavior: Gender differences in the suppression of sexual activity during illness. *Pharmacology, Biochemistry, and Behavior,* **64**(4), 787-796.

Barnum, C. J., Blandino Jr, P., & Deak, T. (2008). Social status modulates basal il-1 concentrations in the hypothalamus of pair-housed rats and alters some aspects of stress reactivity. *Brain, Behavior & Immunity,* **22**(4), 517-527.

Barnum, C. J., Blandino Jr, P., & Deak, T. (2007). Adaptation of corticosterone and hyperthermic responses to stress following repeated stressor exposure. *Journal of Neuroendocrinology,* **19**(8), 632-642.

Black, P. (2002). Stress and the inflammatory response: A review of neurogenic inflammation. *Brain, Behavior & Immunity,* **16**(6), 622-653.

Blandino Jr, P., Barnum, C. J., & Deak, T. (2006). The involvement of norepinephrine and microglia in hypothalamic and splenic il-1 responses to stress. *Journal of Neuroimmunology,* **173**, 87-95.

Bluthe, R. M., Castanon, N., Pousset,, F., Bristow, A., Ball, C., Lestage, J., Michaud, B., Kelley, K.W., & Dantzer, R. (1999). Central injection of il-10 antagonizes the behavioural effects of lipopolysaccharide in rats. *Psychoneuroendocrinology,* **24**(3), 301-311.

Bonilla-Jaime, H., Vazquez-Palacios, G., Arteaga-Silva, M., & Retana-Marquez, S. (2006). Hormonal responses to different sexually related conditions in male rats. *Hormones & Behavior,* **49**(3), 376-382.

Dallman, M. F., Akana, S. F., Cascio, C. S., Darlington, D. N., Jacobson, L., & Levin, N. (1987). Regulation of acth secretion: Variation on a theme of b. *Recent Progress in Hormone Research,* **43**, 113-173.

Dantzer, R. (2004). Cytokine-induced sickness behaviour: A neuroimmune response to activation of innate immunity. *European Journal of Pharmacology,* **500**, 399-411.

Dayas, C., Buller, K., Crane, J., Xu, Y., & Day, T. (2001). Stressor categorization: Acute physical and psychological stressors elicit distinctve recruitment patterns in the amygdala and in medullary noradrenergic cell groups. *European Journal of Neuroscience,* **14**, 1143-1152.

Deak, T. (2007). From hippocampus to dorsal horn: The pervasive impact of il-1 on learning and memory spans the length of the neuroaxis. *Brain, Behavior & Immunity,* **21**(6), 746-747.

Deak, T., Bellamy, C., & Bordner, K. A. (2005a). Protracted increases in core body temperature and interleukin-1 following acute administration of lipopolysaccharide. *Physiology & Behavior,* **85**(3), 296-307.

Deak, T., Bordner, K. A., McElderry, N. K., Bellamy, C., Barnum, C. J., & Blandino Jr, P. (2005b). Stress-induced increases in hypothalamic il-1: A systematic comparison of multiple stressor paradigms. *Brain Research Bulletin,* **64**(6), 541-556

Deak, T., D'Agostino, L. G., Bellamy, C., Rosanoff, M., McElderry, N. K., & Bordner, K. A. (2005c). Behavioral responses during the forced swim test are not affected by anti-inflammatory agents or acute illness induced by lipopolysaccharide. *Behavioural Brain Research,* **160**, 125-134.

Deak, T., Bellamy, C., & D'Agostino, L. G. (2003). Exposure to forced swim stress does not alter central production of il-1. *Brain Research,* **972**, 53-63.

Deak, T., Nguyen, K. T., Cotter, C. S., Fleshner, M., Watkins, L. R., Maier, S. F., et al. (1999a). Long term changes in mineralocorticoid and glucocorticoid receptor occupancy following exposure to an acute stressor. *Brain Research,* **847**, 211-220.

Deak, T., Nguyen, K. T., Fleshner, M., Watkins, L. R., & Maier, S. F. (1999b). Acute stress may facilitate recovery from a subcutaneous bacterial challenge. *Neuroimmunomodulation,* **6**, 344-354.

Deak, T., Meriwether, J. L., Fleshner, M., Spencer, R. L., Abouhamze, A., Moldawer, L. L., Grahn, R.E., Watkins, L.R., & Maier, S.F. (1997). Evidence that brief stress may induce the acute phase response in rats. *American Journal of Physiology,* **273**, R1998-R2004.

Dess, N. K., Raizer, J., Chapman, C. D., & Garcia, J. (1988). Stressors in the learned helplessness paradigm: Effects on body weight and conditioned taste aversion in rats. *Physiology and Behavior,* **44**, 483-490.

Dhabhar, F. S., & McEwen, B. S. (1997). Acute stress enhances while chronic stress suppresses cell mediated immunity in vivo: A potential role for leukocyte trafficking. *Brain, Behavior & Immunity,* **11**, 286-306.

Dunn, A. J., Swiergiel, A. H., & de Beaurepaire, R. (2005). Cytokines as mediators of depression: What can we learn from animal studies? *Neuroscience and Biobehavioral Reviews,* **29**(4-5), 891-909.

Dunn, A. J., & Welch, J. (1991). Stress- and exdotoxin-induced increases in brain tryptophan and serotonin metabolism depend on sympathetic nervous system activity. *Journal of Neurochemistry,* **57**, 1615-1622.

Fleshner, M., Deak, T., Nguyen, K. T., Watkins, L. R., & Maier, S. F. (2002). Endogenous glucocorticoids play a positive regulatory role in the anti-keyhole limpet hemocyanin in vivo antibody response. *Journal of Immunology,* **166**(6), 3813-3819.

Frank, M. G., Barrientos, R. M., Biedenkapp, J., Rudy, J. W., Watkins, L. R., & Maier, S. F. (2006). mRNA upregulation of MHC II and pivotal pro-inflammatory genes in normal brain aging. *Neurobiology of Aging,* **27**(5), 717-722.

Gibertini, M., Newton, C., Friedman, H., & Klein, T. W. (1995). Spatial learning impairment in mice infected with legionella pneumophila or administered exogenous interleukin-1-beta. *Brain, Behavior & Immunity,* **9**(2), 113-128.

Goeders, N. E., & Clampitt, D. M. (2002). Potential role for the hypothalamo-pituitary-adrenal axis in the conditioned reinforcer-induced reinstatement of extinguished cocaine seeking in rats. *Psychopharmacology,* **161**(3), 222-232.

Gorman, J. M., Mathew, S., & Coplan, J. (2002). Neurobiology of early life stress: Non-human primate models. *Semin Clin Neuropsychiatry,* **7**(2), 96-103.

Gronli, J., Murison, R., Fiske, E., Bjorvatn, B., Sorensen, E., Portas, C. M., Ursin, R. (2005). Effects of chronic mild stress on sexual behavior, locomotor activity and consumption of sucrose and saccharine solutions. *Physiology & Behavior,* **84**(4), 571-577.

Guyton, A. C., & Hall, J. E. (2006). Chapter 60: The autonomic nervous system and the adrenal medulla. In *Textbook of medical physiology* (11th ed.). Edinburgh: Elsevier Saunders.

Hart, B. L. (1988). Biological basis of the behavior of sick animals. *Neuroscience and Biobehavioral Reviews,* **12**(123-137).

Hennessy, M. B., Schiml-Webb, P. A., Miller, E. E., Maken, D. S., Bullinger, K. L., & Deak, T. (2007). Anti-inflammatory agents attenuate the passive responses of guinea pig pups: Evidence for stress-induced sickness behavior during maternal separation. *Psychoneuroendocrinology,* **32**(5), 508-515.

Hennessy, M. B., Deak, T., Schiml-Webb, P. A., Wilson, S. E., Greenlee, T. M., & McCall, E. (2004). Behavior of guinea pig pups during isolation in a novel environment: Potential role of the acute phase response. *Physiology & Behavior,* **81**(1), 5-13.

Hennessy, M. B., Deak, T., & Schiml-Webb, P. A. (2001). Stress-induced sickness behaviors: An alternative hypothesis for responses during maternal separation. *Developmental Psychobiology,* **39**, 76-83.

Herman, J., & Cullinan, W. (1997). Neurocircuitry of stress: Central control of the hypothalamo-pituitary-adrenocortical axis. *Trends in Neuroscience,* **20**, 78-84.

Herman, J., Prewitt, C., & Cullinan, W. (1996). Neuronal circuit regulation of the hypothalamo-pituitary-adrenocortical stress axis. *Critical reviews in neurobiology,* **10**(3-4), 371-394.

Johnson, J. D., Campisi, J., Sharkey, C. M., Kennedy, S. L., Nickerson, M., Greenwood, B. N., Fleshner, M. (2005). Catecholamines mediate stress-induced increases in peripheral and central inflammatory cytokines. *Neuroscience,* **135**(4), 1295-1307.

Johnson, J. D., O'Connor, K. A., Deak, T., Spencer, R. L., Watkins, L. R., & Maier, S. F. (2002). Prior stressor exposure primes the HPA axis. *Psychoneuroendocrinology,* **27**, 353-365.

Kaffman, A., & Meaney, M. J. (2007). Neurodevelopmental sequelae of postnatal maternal care in rodents: Clinical and research implications of molecular insights. *Journal of Child Psychology and Psychiatry,* **84**(3-4), 224-244.

Kent, S., Bluthe, R.-M., Kelley, K. W., & Dantzer, R. (1992a). Sickness behavior as a new target for drug development. *Trends in Pharmacological Sciences,* **13**, 24-28.

Kent, S., Bluthe, R. M., Dantzer, R., Hardwick, A. J., Kelley, K. W., Rothwell, N. J., & Vannice, J.L. (1992b). Different receptor mechanisms mediate the pyrogenic and behavioral effects of interleukin-1. *Proceedings of the National Academy of Science,* **89**, 9117-9120.

Maier, S. F., & Watkins, L. R. (1998). Cytokines for psychologists: Implications of bidirectional immune-to-brain communication for understanding behavior, mood, and cognition. *Psychological Review,* **105**(1), 83-107.

Malloy, P. J., Zhao, X., Madani, N. D., & Feldman, D. (1993). Cloning and expression of the gene from candida albicans that encodes a high-affinity corticosteroid-binding protein. *Proceedings of hte National Academy of Science,* **90**(5), 1902-1906.

Marti, O., Marti, J., & Armario, A. (1994). Effects of chronic stress on food intake: Influence of stressor intensity and duration of daily exposure. *Physiology & Behavior,* **55**(4), 747-753.

McEwen, B. S., & Wingfield, J. C. (2003). The concept of allostasis in biology and biomedicine. *Hormones & Behavior,* **43**(1), 2-15.

Milligan, E. D., Nguyen, K. T., Deak, T., Hinde, J. L., Fleshner, M., Watkins, L. R., Maier, S.F. (1998). The long term acute phase-like responses that follow acute stressor exposure are blocked by alpha-melanocyte stimulating hormone. *Brain Research,* **810**, 48-58.

Munck, A., Guyre, P. M., & Holbrook, N. J. (1984). Physiological functions of glucocorticoids in stress and their relation to pharmacological actions. *Endocrine Reviews,* **5**(1), 25-44.

Nguyen, K. T., Deak, T., Will, M. J., Hansen, M. K., Hunsaker, B. N., Fleshner, M., Watkins, L. R., & Maier, S. F. (2000). Time course and corticosterone sensitivity of the brain, pituitary, and serum interleukin-1b protein response to acute stress. *Brain Research,* **859**, 193-201.

Nguyen, K. T., Deak, T., Owens, S. M., Kohno, T., Fleshner, M., Watkins, L. R., Maier, S.F. (1998). Exposure to acute stress induces brain interleukin -1b protein in the rat. *Journal of Neuroscience,* **18**(6), 2239-2246.

Oka, T., Oka, K., & Hori, T. (2001). Mechanisms and mediators of psychological stress-induced rise in core temperature. *Psychosomatic Medicine,* **63**, 476-486.

Pacak, K., & Palkovits, M. (2001). Stressor specificity of central neuroendocrine responses: Implications for stress-related disorders. *Endocrine Reviews,* **22**(4), 502-548.

Pace, T. W., Gaylord, R., Topczewski, F., Girotti, M., Rubin, B., & Spencer, R. L. (2005). Immeidate early gene induction in hippocampus and cortex as a result of novel experience is not directly related to the stressfulness of that experience. *European Journal of Neuroscience,* **22**(7), 1679-1690.

Pecoraro, N., Gomez, F., Laugero, K., & Dallman, M. F. (2002). Brief access to sucrose engages food-entrainable rhythms in food deprived rats. *Behavioral Neuroscience,* **116**(5), 757-776.

Plata-Salaman, C. R., Ilyin, S. E., Turrin, N. P., Gayle, D., Flynn, M. C., Bedard, T., Anisman, H. (2000). Neither acute nor chronic exposure to a naturalistic (predator) stressor influences the interleukin-1beta system, tumor necrosis factor-alpha, transforming growth factor-beta1, and neuropeptide mRNAs in specific brain regions. *Brain Research Bulletin,* **51**(2), 187-193.

Plata-Salaman, C. R., & French-Mullen, S. M. (1992). Intracerebroventricular administration of a specific il-1 receptor antagonist blocks food and water intake suppression induced by lipopolysaccharide. *Physiology and Behavior,* **51**, 1277-1279.

Pugh, C. R., Nguyen, K. T., Gonyea, J. L., Fleshner, M., Watkins, L. R., Maier, S. F., Rudy, J.W. (1999). Role of interleukin-1 beta in impairment of contextual fear conditioning caused by social isolation. *Behavioural Brain Research,* **106**, 109-118.

Retana-Marquez, S., Salazar, E. D., & Velazquez-Moctezuma, J. (1996). Effect of acute and chronic stress on masculine sexual behavior in the rat. *Psychoneuroendocrinology,* **21**(1), 39-50.

Rosenblum, L. A., & Paully, G. S. (1984). The effects of varying environmental demands on maternal and infant behavior. *Child Development,* **55**(1), 305-314.

Roth, J., LeRoith, D., Collier, E. S., Weaver, N. R., Watkinson, A., Cleland, C. F., & Glick, S.M. (1985). Evolutionary origins of neuropeptides, hormones, and receptors: Possible applications to immunology. *Journal of Immunology,* **135**(2), 816-819.

Sawchenko, P., Li, H., & Ericsson, A. (2000). Circuits and mechanisms governing hypothalamic responses to stress: A tale of two paradigms. *Progress in Brain Research,* **122**, 61-78.

Sawchenko, P., Brown, E., Chan, R., Ericsson, A., Li, H., Roland, B., & Kovács K.J. (1996). The paraventricular nucleus of the hypothalamus and the functional neuroanatomy of visceromotor responses to stress. *Progress in Brain Research,* **107**, 201-222.

Schiml-Webb, P. A., Deak, T., Greenlee, T. M., Maken, D., & Hennessy, M. B. (2005). Alpha melanocyte stimulating hormone reverses postulated stress-induced sickness behaviors in isolated guinea pig pups. *Behavioural Brain Research,* **168**(2), 326-330.

Schmidt, E. D., Aguilera, G., Binnekade, R., & Tilders, F. J. (2003). Single administration of interleukin-1 increased corticotropin releasing hormone and corticotropin releasing hormone-receptor mRNA in the hypothalamic paraventricular nucleus which paralleled long-lasting (weeks) sensitization to emotional stressors. *Neuroscience,* **116**(1), 275-283.

Shintani, F. S., Nakaki, T., Kanba, S., Kato, R., & Asai, M. (1995). Role of interleukin-1 in stress responses: A putative neurotransmitter. *Molecular Neurobiology,* **10**, 47-71.

Short, K., & Maier, S. (1993). Stressor controllability, social interaction, and benzodiazepine systems. *Pharmacology, Biochemistry, and Behavior,* **45**, 827-835.

Sorrells, S. F., & Sapolsky, R. M. (2007). An inflammatory review of glucocorticoid actions in the CNS. *Brain, Behavior & Immunity,* **21**(3), 259-272.

Spencer, R. L., Young, E., Choo, P., & McEwen, B. S. (1990). Adrenal steroid type i and type ii receptor binding: Estimates of in vivo receptor number, occupancy, and activation with varying level of steroid. *Brain Research,* **514**, 37-48.

Uphouse, L., Selvamani, A., Lincoln, C., Morales, L., & Comeaux, D. (2005). Mild restraint reduces the time hormonally primed rats spend with sexually active males. *Behavioural Brain Research,* **157**(2), 343-350.

Whitton, P. S. (2007). Inflammation as a causative factor in the aetiology of Parkinson's disease. *British Journal of Pharmacology,* **150**(8), 963-976.

Woodmansee, W. W., Silbert, L. H., & Maier, S. F. (1993). Factors that modulate inescapable shock-induced reductions in daily activity in the rat. *Pharmacology, Biochemistry and Behavior,* **45**, 553-559.

International Journal of Comparative Psychology, 2007, **20,** 111-120.
Copyright 2007 by the International Society for Comparative Psychology

The Behavioral Ecology of Disturbance Responses

Colin M. Beale
Macaulay Institute, United Kingdom

Measuring the impacts of anthropogenic activities on wildlife is crucial for ensuring effective management. Animal behavior is often considered a sensitive index of impact, but its use requires detailed understanding of the context dependent decisions animals make. In this manuscript I identify a number of areas where insights from the field of animal behavior are relevant to studies of human disturbance and activity. In particular, I differentiate between disturbance effects and disturbance impacts and show how context-dependent decision-making often makes animal behavior an unreliable index of impact. I show the areas where animal behavior can be useful in quantifying minimum disturbance impact when additional information is available, and identify a number of areas where further research may help improve the management of anthropogenic activities within wildlife areas.

The effective management of human activities in wildlife areas is an important conservation issue, as the footprint of human influence continues to expand (Green, Cornell, Scharlemann & Balmford, 2005) and incidental impacts of human activities (e.g. noise and disturbance) spread into more areas (Keirle, 2002; Hatch & Wright, this issue; Weilgart, this issue). Such expanding anthropogenic activity is widely perceived to lead to negative consequences for the wildlife beyond habitat loss alone (Frid, 2003; Higham, 1998; Stevens & Boness, 2003; Taylor & Knight, 2003; de la Torre, Snowdon & Bejarano, 2000; Wauters, Somers, & Dhondt, 1997). Understanding how animals respond to noise and more generally, anthropogenic activities is fundamental to resolving potential conflicts between humans and animals (Hatch & Wright, this issue; Weilgart, this issue; Wright et al., this issue, a). There are numerous ways in which it is possible to study animal responses, but changes in an animal's behavior are often the most obvious consequences of anthropogenic activities so it is not surprising that many authors use behavioral observations to understand impacts (Fortin & Andruskiew, 2003; Nettleship, 1972). However, interpretation of the results of animal behavior studies is not always straightforward and while the study of behavior within a conservation context is to be encouraged (Sutherland, 1998) insights from the wider field of animal behavior will have direct relevance to understanding. In this paper I review a number of areas where understanding animal behavior offers insights of management importance in understanding how animals may respond to human activities. This is not an attempt to fully review the impacts of anthropogenic activities on animal behavior, but rather to highlight a few important insights that have sometimes been overlooked in conservation studies (Buchholz, 2007; Sutherland, 1998).

Animal behavior is an eclectic field with a scope that ranges from purely behavioral observation (the assessment of the amount of time an animal

Much of the work described in this article was undertaken whilst supported by a University of Glasgow scholarship. I would like to thank P. Monaghan, J. Gill & W. J. Sutherland for useful discussions of the issues described and all the workshop participants for helping clarify important points to include. D. Blumstein and one anonymous referee provided additional suggestions that have helped improve the paper. Correspondence concerning this article should be addressed to Colin Beale, Macaulay Institute; Craigiebuckler, Aberdeen, AB15 8QH, UK. (c.beale@macaulay.ac.uk).

spends doing various activities, for example), through questions relating to resource allocation (how many offspring to have in a litter, how much testosterone to place in an egg, etc.) to more psychological questions of how animals perceive their environment (when in a foraging patch, how long do animals remember recent weather events, etc.) (Alcock, 2003; Buchholz, 2007). Underlying the field is an attempt to understand how animals make decisions and what the consequences of these decisions are. In this paper I will attempt to show how understanding from a number of different areas of animal behavior has implications for understanding how noise and other anthropogenic disturbance is likely to impact animal conservation and welfare, starting with the simplest observations of animal behavior.

Behavioral responses to threatening stimuli

Perhaps the most obvious of the responses an animal makes to a threatening stimulus are simple behavioral responses. It is therefore unsurprising that measuring behavioral responses such the distance at which an animal flees or first responds to human presence have therefore been widely used to address a number of related questions about the impacts of disturbance. Primary among these is the simple question: does human disturbance affect animals (Blumstein, Anthony, Harcourt, & Ross, 2003; Klein, Humphrey, & Percival, 1995; Tuite, Hanson, & Owen, 1984)? Behavioral measures have also been used when human disturbance effects are assumed and the question is more to identify which populations or species are most susceptible to disturbance (Blumstein, Fernández-Juricic, Zollner, & Garity, 2005; Tarlow & Blumstein, 2007). However, behavioral responses involve the animal making a number of different decisions, so a naïve exploration of the simple behavioral response may be inadequate.

For example, on first hearing a noise, a feeding animal may stop foraging and look around for the source. If the noise or its source is threatening enough, the animal's stress response pathways may be activated at this point, the short- and long-term physiological consequences of which are highlighted elsewhere (e.g. Deak, this issue; Romero & Butler, this issue). What an animal decides to do about this threat, however, is not fixed: it may choose to simply keep a wary eye on the threat and resume feeding, or it may flee the area to feed in a safer location. Let us assume the noise is caused by a one-off, short-term stimulus and the animal chooses to abandon the area temporarily but will return when the threat has passed. This is a short-term response to a short-term stimulus and the costs of this response are likely to fall well within the norms the animal is used to (i.e. homeostasis is maintained: Romero, 2004) so this would be an appropriate decision for the animal to make. However, if the stimulus is repeated frequently, the cost of repeated short-term responses (lost foraging time, costs of flight, etc.) may accrue meaning that an animal in the frequently disturbed environment may decide that staying put but maintaining a constant readiness to leave is less costly than fleeing. This may result in increased energetic expenditure and chronic stress with all the physiological consequences associated (Deak, this issue; Romero & Butler, this issue), but is still an appropriate decision if the costs involved in repeatedly leaving the feeding area are greater than the physiological consequences of chronic stress. If we are to accurately interpret behavioral responses to a disturbance event,

therefore, it is crucial that we understand the *context* within which an animal makes decisions.

Before continuing further, it is important to note that the *effects* of a disturbance event are not necessarily the same as the *impacts* of that disturbance event. E.G., in the first example above the effect of the one-off disturbance was to make the animal temporarily leave a feeding area, an effect that was not shown by the animal in the second example. Leaving a foraging area might be assumed to be a negative impact (as noted by Gill, Norris, & Sutherland, 2001a), but the impact is likely to be largely negligible compared with the impact on the animal subjected to repeated stimuli in the second example that showed no behavioral effect but may suffer physiological consequences. If we are interested in conservation and welfare, we are clearly much more interested in impacts than simple effects (Gill et al., 2001a; Gill, Sutherland, & Watkins, 1996; Nisbet, 2000). This crucial difference is often ignored when researchers equate effect with impact: certainly human disturbance affects animal behavior, but this does not necessarily mean human disturbance has a (negative) impact on animal conservation or welfare. The previous example illustrates one case where the behavioral measure (whether or not an animal left the area) is clearly not an appropriate index of the impact of the disturbing stimuli. More generally, Gill et al. (2001a) suggested that a lack of behavioral response may not imply a lack of fitness consequence but may instead reflect a lack of choice and Beale & Monaghan (2004a) provided an empirical test showing that such theoretical arguments translate directly to the field and concluded that it is wrong to assume that the most responsive animals are those that are most vulnerable to disturbance.

It seems that context-dependent decision-making behavior therefore limits the practical utility of recording behavioral responses as an index of the impact of stressful stimuli. I therefore consider that ignoring context and using simple behavioral measures as a direct mechanism for assessing either whether animals will suffer impacts of disturbance, or for identifying which populations or species may be most vulnerable to disturbance is seriously flawed. This, however, does not necessarily mean that behavioral measurements cannot be useful for researchers interested in impacts of human disturbance provided the context under which the behavioral decisions are made is understood and no direct link between behavioral effect and disturbance impact is assumed. For example, instead of assuming effect and impact are identical, if behavioral responses are coupled with further information on the costs of the changed behavior itself a *minimum* estimate of the cost of responding can be estimated. In the earlier example an estimate of the energetic costs of lost foraging time and energy spent moving away can be estimated and put in the context of daily energy expenditure. However, for the animal that showed no behavioral response the estimated cost would be zero but as we have already seen this animal is actually much more likely to suffer stress-related impacts than the first animal. Thus estimates of cost based on behavior alone are likely to be underestimates and if the estimated cost is low it does not mean that the impact of the stimulus is necessarily low. It is also clear that this method does not allow comparison between populations or species. If the minimum cost is put in an appropriate context where its importance can be measured against other energetic costs and it can be shown that animals are not compensating for such increased energetic expenditure (e.g. by feeding at night: Lane & Hassall,

1996), the minimum potential for negative impacts can be assessed and may be substantial (Williams, Lusseau, & Hammond, 2006).

Similarly, if the context in which decisions are made is not changed, behavioral measures can be used directly to measure the relative degree to which stressors affect individuals. However, maintaining similarity of context is challenging and variations must be strictly controlled experimentally and/or statistically. If, for example, the degree of impact caused by two different types of boat engine is of interest it may be possible to approach the same individual animals in the same location at the same time of day over a relatively short time span with the two different engines and record the behavioral responses. If one engine type consistently results in greater behavioral responses it is very likely that this engine type is perceived to be a stronger stressor than the alternative. It is crucial, however, that the context is maintained as constant as possible when assessing the impact of the two potential stressors: the individuals must be the same, in the same size group, engaged in the same activity when first approached and in the same location. If any of these variables has changed, the context in which the animals find themselves will also have changed and the results will be highly suspect unless tightly controlled statistically. Statistical control may be appropriate, for example, if the number of individuals within a group is variable and group-size alters behavioral response in a predictable manner: in such cases inclusion of a group-size variable in statistical analysis will go some way to controlling for this aspect of context.

Impacts of avoidance behavior

Perhaps the next stage of assessing the impacts of behavioral responses to threatening stimuli involves asking questions about the redistribution of animals (i.e. avoidance) that is widely observed in areas where frequent disturbances are likely (Tarlow & Blumstein, 2007; Weilgart, this issue). What is the cost to the animals of this avoidance? Does it limit population in some way?

Although not yet widely applied, resource-use based models have been used as one way of assessing the population consequences of avoidance behavior (Fernández-Juricic, Sallent, Sanz, & Rodríguez-Prieto,, 2003; Gill et al., 1996; Gill, Norris, & Sutherland, 2001b; Percival, Sutherland, & Evans, 1998). Such models develop a behavior-based model to assess the impact of human disturbance, but do not rely on directly measuring the behavioral responses animals show to human presence. Instead, they assume that animals show behavioral responses to humans but suggest that if any significant fitness costs are associated with such responses, a critical, limiting resource will be under-used. Therefore, patterns of resource use are determined instead of measuring behavior directly. If resources are under-utilized in areas where disturbance is high, human disturbance is regarded as having an impact of conservation concern. For example, Gill et al. (2001b) report a study of the effect of disturbance on the Black-tailed Godwit. They showed that, despite this species being perceived as sensitive to human disturbance, no under-use of food resources was detected, presumably either because the birds fed in the most disturbed areas at times when there were few disturbances (e.g. early mornings), or because the birds chose to use the disturbed areas once resources

were used up in undisturbed areas. They therefore conclude that although these animals appear to avoid human presence, this does not reduce the population size supported by the estuaries they studied. Similar issues have been studied using simulation models: Stillman et al. (2000) used an individual based model to show that avoidance behavior may lead to population decline and Blumstein et al. (2005) used a simple model to show that resource use may fall in disturbed areas but neither studies include context-based decision making.

Studies of resource use have so far focused on utilization of food supplies (Fernández-Juricic, Sallent, Sanz, & Rodríguez-Prieto, 2003; Gill et al., 1996; Gill et al., 2001b) and wintering habitat (Percival et al., 1998), but could also be used in relation to other resources, including breeding territories. However, such studies rely heavily on the correct identification of critical resources. If the effect of disturbance was measured on the use of the wrong resource, it would be possible to incorrectly conclude that human disturbance was not an important factor. It is possible, for example, that the utilization of food resources is unaffected by human disturbance, but that resting sites are negatively affected and the population declines because there are insufficient disturbance free areas to rest. Alternatively, it might be possible to wrongly identify human disturbance as limiting populations for similar reasons. For example, if some other external factor holds an animal's population artificially low (e.g. hunting pressure on migration) and these animals show avoidance of humans, they may not make full use of resources in disturbed areas: not all available resources are required to maintain the population so the animals never need to use the resources in more disturbed areas. However, it would be wrong to assume that this pattern of resource use provided evidence that disturbance was implicated in the low population of this species. If the population were to increase (e.g. because hunting pressure is reduced), animals might eventually decide to forage in the more disturbed areas because these previously unexploited resources are now required to maintain the increased population.

On the other hand, if animals do avoid areas with a high frequency of anthropogenic activity and under-use a particular resource or habitat, negative impacts are still not necessary consequences. For example, Mallord, Dolman, Brown, & Sutherland (2007) showed that woodlarks *Lullula arborea* avoided heavily visited habitat. This resulted in fewer individuals breeding in visited areas, but the few birds that did so were freed from competition and enjoyed increased breeding success, with the total number of fledglings from disturbed heaths approximately equal to the number of fledglings from undisturbed heaths where birds were breeding in higher densities. The overall population is therefore determined by a delicate balance between the improvement in breeding success due to density dependent effects and the reduction in habitat availability due to (inappropriate) disturbance avoidance. Whether this balance leads to a stable population or one in decline can only be determined by assessing disturbance impacts across the entire area of suitable habitat and estimating the number of animals that this could support in the absence of human disturbance. This, and especially the effect that might occur when disturbance is seasonal and otherwise perfect habitat becomes poor after animals have settled in the area (e.g. at holiday times) can be seen as forms of an ecological trap (i.e. anthropogenic activities have altered habitat quality

such that the cues an animal uses to select a habitat are no longer appropriate: (Kokko & Sutherland, 2001).

Other measures of impacts of threatening stimuli

Other methods for determining the impacts of anthropogenic stressors have recently been reviewed elsewhere and I shall not attempt this here (Tarlow & Blumstein, 2007). However, methods involving the measurement of physiological and metabolic parameters associated with stress responses are relevant to a discussion of animal behavior because they help explain how impacts may occur even in the absence of behavioral responses.

Some penguins are noted for their lack of behavioral responses to visitors, especially in areas where visitors are frequent (e.g. Nimon, Schroter, & Stonehouse, 1995; Fowler, 1999). This lack of response led to the suggestion that these birds are "habituated", a claim also made for other species (Nisbet, 2000) but, if a real phenomenon, it is more likely to refer to learned non-response as physiological acclimation seems unlikely (Wright et al., this issue). For example, Fowler (1999) studied the hormonal and behavioral responses of penguins in areas of differing disturbance. Fowler showed no difference in physiological responses between birds in medium and low disturbance plots, but found a significantly decreased hormonal response in the high disturbance areas, indicative of acclimation. However, as variation was large in the control plots but small in the disturbed plots the results suggest that, rather than birds acclimating, birds that showed high responses left the area. This is further suggested by the lower nesting density in the high disturbance plot (Fowler, 1999). Fowler also showed that average strength of the behavioral responses in each plot decreased with visitor levels, but did not examine the relationship between an individual's hormonal and behavioral responses.

Additional work on the heart-rate of kittiwakes *Rissa tridactyla* and European shag *Phalacrocorax aristotelis* with a long history of exposure to human visitors also highlighted extreme individual variation in heart-rate responses to disturbance (Beale, 2004). These studies found that even when negligible changes in behavior were observed in response to a potentially threatening stimulus, heart rate of those birds that do respond could increase by 50%. This clearly indicates that these birds are likely to be experiencing physiological stress responses which must be considered chronic in areas with frequent disturbance events. However, a raised heart-rate may itself have conservation consequences, as maintaining raised heart-rates requires increased metabolic costs which may, in turn, affect demographic parameters. I estimated an increase of 7.5 – 10% in daily energy expenditure for some individual Kittiwakes in Scotland (Beale, 2004), an increase likely to result in eventual abandonment of nesting attempts once energy reserves drop below a critical level: this is indeed the proposed mechanism linking anthropogenic activity to nesting failure in this species (Beale & Monaghan, 2004b). It is also worth noting that individualistic heart-rate responses to human disturbance again indicate the importance of understanding animal behavior, where some individuals choose to respond, and others not. Only by understanding that there are susceptible and unsusceptible individuals can the observed change in breeding success be comprehended, not by simply considering the mean response of the population.

It is, of course, important to question whether even declines in breeding success reflect an impact of genuine conservation concern. Indeed, breeding success is not necessarily a good surrogate of fitness thanks in part to density dependent effects (Frederiksen, Lebreton, & Bregnballe, 2001; Olijnyk & Brown, 1999). Moreover, breeding success is often far less important in determining populations of relatively long-lived animals than winter mortality (Russell, 1999; Weimerskirsch, Brothers, & Jouventin, 1996), a distinction likely to hold for many long-lived species. A decrease in breeding success of 9%, as observed for Kittiwakes in Scotland is, in fact, unlikely to have a major impact on the population as a whole.

Conclusions

Understanding that animals are individuals that make context-dependent decisions about how to respond to their environment results is an important insight with practical application to understanding how animals respond to anthropogenic stimuli. It is also crucial to differentiate between disturbance effect and disturbance impact. I have shown how this context-dependent decision making means the use of simple behavioral indices as a direct measure of disturbance impact is unsound, and have pointed out areas where incorporating further information can make behavior measures potentially useful. I have shown how the decisions animals make about where to feed and breed can be influenced by human activities and the consequences or otherwise this might have for the population. I have shown that in birds at least, it is clear that disturbance from anthropogenic activity can reduce breeding success even in the absence of behavioral effects. I have also shown how even physiological responses to anthropogenic activity can be individualistic, indicating that a more profound understanding of these responses also required understanding decision making behavior. Throughout, I have attempted to stress the distinction between effects and impacts, a distinction that is crucially important when making management decisions. Research on the effects of human disturbance is slowly taking account of the need to understand behavior (Fernández-Juricic et al., 2003; Gill et al., 2001b; Stillman et al., 2000), though papers continue to be published that overlook context-dependant decision-making behavior (Frid, 2003; Fortin & Andreskiew, 2003; Fernández-Juricic, Vaca, & Schroeder, 2004; Blumstein et al., 2005).

Future work on disturbance impacts is likely to be valuable and the impact of recreation on biodiversity has been identified as one of the 100 ecological questions of high policy relevance in the UK (Sutherland et al., 2006). Future efforts must distinguish between effect and impact and must adequately incorporate context-dependent decision making behavior. Although behavioral measures are inappropriate for assessing the comparative impact of disturbance on multiple species (even at the same location different species will experience the environment differently and will find themselves in different contexts), there is clearly a need to identify methods to protect multiple species (Blumstein et al., 2005). It is likely that further advances may be made through the use of individual based models that allow individuals to make truly context-dependent decisions. Further studies that identify disturbance effects at multiple levels – behavioral, physiological and metabolic

– are likely to improve understanding of disturbance impacts. Finally, I believe that more study of the behavior of people in wildlife areas is likely to offer new insights into how to manage conflicts between humans and wildlife. This aspect of human disturbance research is currently largely neglected, but must be considered a crucial part of the equation.

References

Alcock, J. (2003). A textbook history of animal behaviour. *Animal Behaviour,* **65**, 3-10.

Beale, C. M. (2004). The effects of human disturbance on breeding and foraging birds. Unpublished Ph.D. Thesis. University of Glasgow, UK.

Beale, C. M., & P. Monaghan. (2004a). Behavioural responses to human disturbance: a matter of choice? *Animal Behaviour,* **68**, 1065-1069.

Beale, C. M., & P. Monaghan. (2004b). Human disturbance: People as predation free predators? *Journal of Applied Ecology,* **41**, 335-343.

Blumstein, D. T., Fernández-Juricic, E., Zollner, P. A. & Garity, S. C. (2005). Inter-specific variation in avian responses to human disturbance. *Journal of Applied Ecology,* **42**, 943-953.

Blumstein, D. T., Anthony, L. L., Harcourt, R. & Ross, G. (2003). Testing a key assumption of wildlife buffer zones: Is flight initiation distance a species-specific trait? *Biological Conservation,* **110**, 97-100.

Buchholz, R. (2007). Behavioural biology: An effective and relevant conservation tool. *Trends in Ecology & Evolution,* **22**, 401-407.

Deak, T. (2007). From classic aspects of the stress response to neuroinflammation and sickness: Implications for individuals and offspring of diverse species. *International Journal of Comparative Psychology,* **this issue**, 96-110.

Fernández-Juricic, E., Vaca, R. & Schroeder, N. (2004). Spatial and temporal responses of forest birds to human approaches in a protected area and implications for two management strategies. *Biological Conservation,* **117**, 407-416.

Fernández-Juricic, E., Sallent, A., Sanz, R. & Rodríguez-Prieto, I. (2003). Testing the risk-disturbance hypothesis in a fragmented landscape: Nonlinear responses of house sparrows to humans. *The Condor,* **105**, 316-326.

Fortin, D. & Andruskiew, M. (2003). Behavioral response of free-ranging bison to human disturbance. *Wildlife Society Bulletin,* **31**, 804-813.

Fowler, G. S. (1999). Behavioural and hormonal responses of Magellanic penguins (*Spheniscus magellanicus*) to tourism and nest site visitations. *Biological Conservation,* **90**, 143-149.

Frederiksen, M., Lebreton, J. D. & Bregnballe, T. (2001). The interplay between culling and density dependence in the Great Cormorant: A modelling approach. *Journal of Applied Ecology,* **28**, 617-627.

Frid, A. (2003). Dall's sheep responses to overflights by helicopter and fixed-wing aircraft. *Biological Conservation,* **110**, 387-399.

Gill, J. A., Norris, K. & Sutherland, W. J. (2001a). Why behavioural responses may not reflect the population consequences of human disturbance. *Biological Conservation,* **97**, 265-268.

Gill, J. A., Norris, K. & Sutherland, W. J. (2001b). The effects of disturbance on habitat use by Black-tailed Godwits *Limosa limosa*. *Journal of Applied Ecology,* **38**, 846-856.

Gill, J. A., Sutherland, W. J. & Watkinson, A. R. (1996). A method to quantify the effects of human disturbance on animal populations. *Journal of Applied Ecology,* **33**, 786-792.

Green, R. E., Cornell, S., Scharlemann, J. P. W., & Balmford, A. (2005). Farming and the fate of wild nature. *Science*, ***307***, 550-555.

Hatch, L. & Wright, A. J. (2007). A brief review of anthropogenic sound in the oceans. *International Journal of Comparative Psychology*, **this issue**, 121-133.

Higham, J. E. S. (1998). Tourists and albatrosses: The dynamics of tourism at the Northern Royal Albatross Colony, Taiaroa Head, New Zealand. *Tourism Management*, **19**, 521-531.

Keirle, I. (2002). Should access to the coastal lands of Wales be developed through a voluntary or statutory approach? A discussion. *Land Use Policy*, **19**, 177-185.

Klein, M. L., Humphrey, S. R. & Percival, H. F. (1995). Effects of eco-tourism of distribution on waterbirds in a wildlife refuge. *Conservation Biology*, **9**, 1454-1465.

Kokko, H. & Sutherland, W. J. (2001). Ecological traps in changing environments: Ecological and evolutionary consequences of a behaviourally mediated Allee effect. *Evolutionary Ecology Research*, **3**, 537–551.

Lane, S. J & Hassall, M. (1996). Nocturnal feeding by Dark-bellied brent Geese *Branta bernicla bernicla. Ibis*, **138**, 291-297.

Mallord, J.W., Dolman, P.M., Brown, A. F. & Sutherland, W.J. (2007). Linking recreational disturbance to population size in a ground-nesting passerine. *Journal of Applied Ecology*, **44**, 185–195.

Nettleship, D. N. (1972). Breeding success of the Common Puffin (*Fratercula arctica* L.) on different habitats at Great Islands, Newfoundland. *Ecological Monographs*, **42**, 239-268.

Nimon, A. J., Schroter, R. C. & Oxenham, K. C. (1996). Artificial eggs: Measuring heart rate and effects of disturbance in nesting penguins. *Physiology and Behaviour*, **60,** 1019-1022.

Nimon, A. J., Schroter, R. C. & Stonehouse, B. (1995). Heart rate of disturbed penguins. *Nature*, **374**, 415.

Nisbet, I. C. (2000). Disturbance, habituation, and management of waterbird colonies. *Waterbirds*, **23**, 312-332.

Olijnyk, C. G. & Brown, K. M. (1999). Results of a seven year effort to reduce nesting by Herring and Great Black-backed Gulls. *Waterbirds*, **22**, 285-289.

Percival, S. M., Sutherland W. J. & Evans, P. R. (1998). Intertidal habitat loss and wildfowl numbers: Application of a spatial depletion model. *Journal of Applied Ecology*, **35**, 57-63.

Romero, L. M. (2004). Physiological stress in ecology: Lessons from biomedical research. *Trends in Ecology and Evolution*, **19**, 249-255.

Romero, L. M. & Butler, L. K. (2007). Endocrinology of Stress. *International Journal of Comparative Psychology*, ***this issue***, 89-95.

Russell, R. W. (1999). Comparative demography and life history tactics of seabirds: Implications for conservation and marine monitoring. *American Fisheries Society Symposium*, **23**, 51-76.

Stevens, M. A. & Boness, D. J. (2003). Influences of habitat features and human disturbance on use of breeding sites by a declining population of southern fur seals (*Arctocephalus australis*). *Journal of Zoology*, **260**, 145-152.

Stillman, R. A., Goss-Custard, J. D., West, A.. D., Dit Durell, S. E. A. le V., Caldow, R. W. G., McGrorty, S. & Clarke, R. T. (2000). Predicting mortality in novel environments: tests and sensitivity of a behaviour-based model. *Journal of Applied Ecology*, **37**, 564-588.

Sutherland, W.J. (1998). The importance of behavioural studies in conservation biology. *Animal Behaviour*, **56**, 801-809.

Sutherland, W.J. et al. (2006). The identification of 100 ecological questions of high policy relevance in the UK. *Journal of Applied Ecology*, **43**, 617-627.

Tarlow, E. M. & Blumstein, D. T. (2007). Evaluating methods to quantify anthropogenic stressors on wild animals. *Applied Animal Behaviour Science,* **102**, 429-451.

Taylor, A. R. & Knight, R. L. (2003). Wildlife responses to recreation and associated visitor perceptions. *Ecological Applications,* **13**, 951-963.

de la Torre, S., Snowdon, C. T. & Bejarano, M. (2000). Effects of human activities on wild pygmy marmosets in Ecuadorian Amazonia. *Biological Conservation,* **94**, 153-163.

Tuite, C. H., Hanson, P. R. & Owen, M. (1984). Some ecological factors affecting winter wildfowl distribution on inland waters in England and Wales, and the influence of water-based recreation. *Journal of Applied Ecology,* **21**, 41-62.

Wauters, L. A., Somers, L. & Dhondt, A. A. (1997). Settlement behaviour and population dynamics of reintroduced red squirrels *Sciurus vulgaris* in a park in Antwerp, Belgium. *Biological Conservation,* **82**, 101-107.

Weilgart, L. S. (2007). A brief review of known effects of noise on marine mammals. *International Journal of Comparative Psychology,* **this issue**, 159-168.

Weimerskirsch, H., Brothers, N. & Jouventin, P. (1996). Population dynamics of Wandering Albatross *Diomedia exulans* and Amsterdam Albatross *Diomedia amsterdamensis* in the Indian Ocean and their relationships with long-line fisheries: Conservation implications. *Biological Conservation,* **79**, 257-270.

Williams, R. M., Lusseau, D. & Hammond, P. S. (2006). Estimating relative energetic costs of human disturbance to killer whales (Orcinus orca). *Biological Conservation,* **133**, 301-311.

Williams, R. M., Trites, A. W. & Bain, D. E. (2002). Behavioural responses of killer whales (Orcinus orca) to whale-watching boats: Opportunistic observations and experimental approaches. *Journal of Zoology (London),* **256**, 255-270.

Wright, A. J., Aguilar Soto, N., Baldwin, A. L., Bateson, M., Beale, C., Clark, C. et al. V. (2007a). Anthropogenic noise as a stressor in animals: A multidisciplinary perspective. *International Journal of Comparative Psychology,* **this issue**, 250-273.

International Journal of Comparative Psychology, 2007, **20**, 121-133.
Copyright 2007 by the International Society for Comparative Psychology

A Brief Review of Anthropogenic Sound in the Oceans

Leila T. Hatch
Gerry E. Studds Stellwagen Bank National Marine Sanctuary
U.S. National Oceanic and Atmospheric Administration, U.S.A.

Andrew J. Wright
Leviathan Sciences, U.S.A.

Sound in the oceans is generated by a variety of natural sources, such as breaking waves, rain, and marine animals, as well as a variety of human-produced sources, such as ships, sonars and seismic signals. This overview will begin with a quick review of some basic properties of sound waves with particular reference to differences between the behaviours of these waves underwater versus in air. A basic understanding of the physics of underwater sound is critical to understanding how marine animal acoustic signals have evolved relative to their different functions and how changes in the marine acoustic environment due to increasing anthropogenic sound in the oceans may impact these species. We will then review common sources of anthropogenic sound in the oceans. The frequency contributions of three major sources of underwater anthropogenic sound and their relative intensities will be discussed: naval exercises, seismic surveys and commercial shipping. Finally, a case study examining relative inputs to a regional noise budget, that of the Gerry E. Studds Stellwagen Bank National Marine Sanctuary, will be presented to introduce the audience to methodologies for characterizing and managing sound on an ecosystem level.

A number of reviews of anthropogenic sound in the oceans (and its effects on marine mammals) have described properties of underwater sound, outlined the differences between the transmission of sound underwater versus in air and compared acoustic characteristics associated with different types of anthropogenic sources (e.g., Hildebrand, 2005; MMC, 2007; Nowacek, Thorne, Johnston, & Tyack, 2007; NRC, 1994, 2003; Richardson, Greene, Malme, & Thomson, 1995). This paper will not attempt to provide the same detailed coverage of these topics. Instead, this paper will provide a basic introduction to the sources and physics of underwater sound for the uninitiated audience and provide references for the interested reader to gain additional information.

The reviews noted above also include thorough examination of the current scientific knowledge surrounding the effects of underwater noise on marine mammals; however, Weilgart (this issue) provides a brief overview of this material. Furthermore, natural sources of sound in the oceans will not be detailed here. This is not because these sounds do not affect marine mammals, but because management of underwater noise focuses on human contributions to the marine acoustic environment, in which sound plays important natural roles.

What Is Sound? A Primer

Sound is a compression wave that causes particles of matter to vibrate as it transfers from one to the next. These vibrations produce relatively small changes in

The views expressed in this paper are those of the authors alone and do not represent those of Stellwagen Bank National Marine Sanctuary, the U.S. National Marine Sanctuary Program and/or NOAA. Thanks are due to 2 anonymous reviewers for their helpful comments on an earlier version of this manuscript. Correspondence concerning this article should be addressed to Leila Hatch, Gerry E. StuddsStellwagen Bank National Marine Sanctuary, U.S.A. (leila.hatch@noaa.gov).

pressure (compared to atmospheric pressure) that can be detected by the ear.

Depicted graphically as a sine wave, the wavelength of a sound is equal to the speed of sound divided by its frequency. Thus, high-frequency sounds have shorter wavelengths than low-frequency sounds travelling in the same medium (Figure 1). The perceived "loudness" of a sound is a function of its amplitude (i.e., how much energy it carries) or intensity (the power of the wave transmitted in a particular direction in watts per square meter) and the hearing thresholds of the receiver (i.e., listener). It should be noted that the speed of sound in seawater is the same for all frequencies, but varies with aspects of the local marine environment such as density, temperature and salinity. Due mainly to the greater "stiffness" of seawater relative to air, sound travels approximately 1,500 m/s in seawater while it travels only approximately 340 m/s in air. Boundaries between two mediums with very different sound speeds act somewhat like mirrors to all sound not striking that boundary perpendicularly. Consequently, sound does not travel well between air and the oceans.

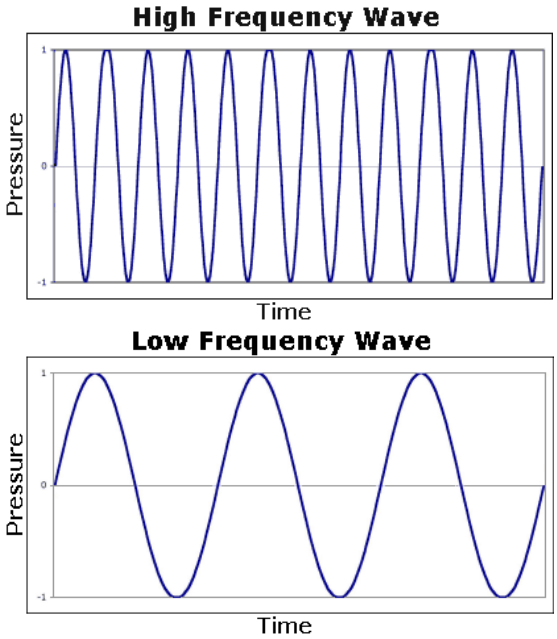


Figure 1. This diagram shows a high frequency wave (above) and a low frequency wave (below), plotted as pressure versus time. The high frequency wave has completed twelve cycles over the time shown. The low frequency wave has completed only three cycles over the same time. Diagram reproduced with permission from *Discovery of Sound in the Sea* http://www.dosits.org/ (a).

A sound's intensity is usually measured in decibels (dB), which is a relative measurement rather than an absolute measurement of wave's directional energy. Measurements in air usually reference 20 micropascals (µPa), or about the sound of a pin drop, while the standard reference in seawater is 1 µPa. Converting between sound intensities in air and water can be confusing and often the source of conflict. This is not only due to the relative nature of the decibel scale, but also the

relationship between a sound's intensity and the medium it is travelling through, in addition to the different methods for measuring the level of a sound. Sound waves with the same *intensities* in water and air when measured in watts per square meter have relative *intensities* that differ by 61.5 dB. Thus, for sounds with the same absolute *intensities* in watts per square meter, one must subtract 61.5 dB to obtain the sound's relative intensities in water referenced to 1 μPa. Reference intensities cause 26 dB of this difference, while the differences in densities and sound speeds account for the other 35.5 dB of the difference in *intensities* (Urick, 1983).

As mentioned above, there are different ways to characterize a signal's amplitude. The most common methods are to measure peak-to-peak pressure, peak pressure, and root mean squared (rms). Peak-to-peak amplitude is represented in the waveform by the entire height of the sound wave, peak pressure would be the largest displacement from the central line and rms measures the average of the pressure of the sound signal over a given duration. Due to its direct relationship to the amount of energy carried by the sound wave (i.e., intensity), the rms pressure is the most common metric used to characterize sound waves (Madsen, 2005).

As a result of the physical and measurement differences described above, sounds with equal absolute intensities in seawater and air have higher relative intensity, travel faster and go farther before they loose their energy in seawater than in air. In addition, regardless of the medium the sound is travelling through, low frequency sounds travel farther than high frequency sounds because their energy is absorbed more slowly and louder sounds travel farther than softer sounds because they have more energy to disperse over distance from the source.

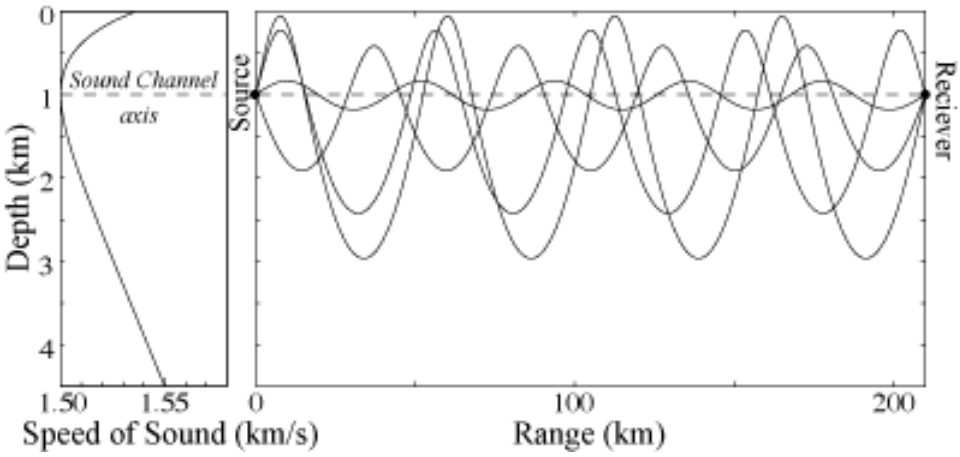


Figure 2. This diagram shows the sound channel axis. Sound speed profile from mid-latitudes is represented on the left. The paths that sound travels from a source at 1000m depth to a receiver at 1000m depth and 210km away from the source are shown on the right. Diagram reproduced with permission from *Discovery of Sound in the Sea* http://www.dosits.org/ (b) and adapted from Figure 1.1 of Munk, Worcester, & Wunsch (1995).

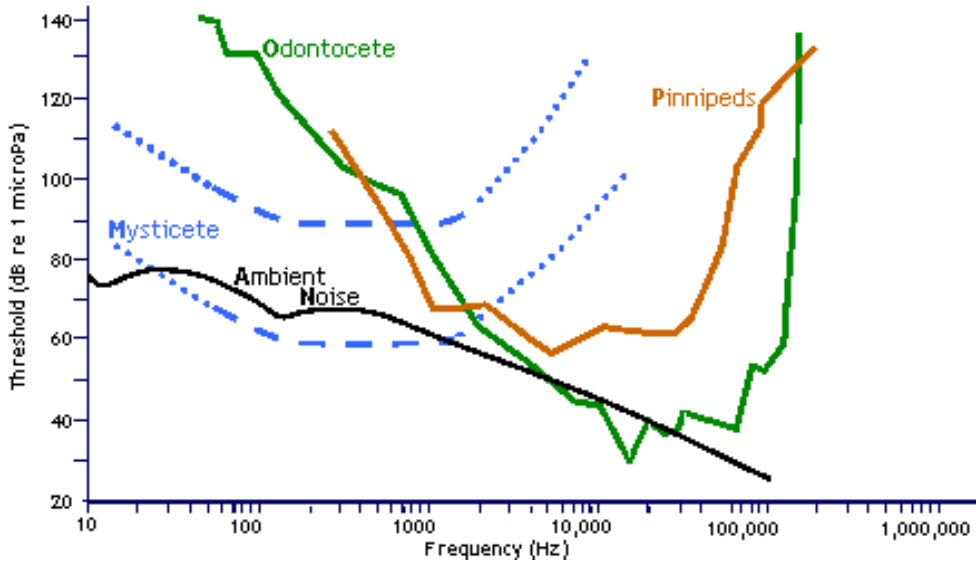


Figure 3. Estimates of the hearing thresholds for mysticetes, odontocetes and pinnipeds with ambient noise profile superimposed. The y-axis is relative intensity in underwater dB. The x-axis is the frequency of a sound on a logarithmic scale. Figure modified with permission from *Discovery of Sound in the Sea* http://www.dosits.org/ (c).

In the majority of the ocean there is often a minimum sound speed due to the predominant effects of heat from the sun and density due to depth on the speed of sound in water (salinity also plays a major role where it varies widely, such as near shore and in estuaries). The increasing sound speeds above and below this minimum tend to focus sounds like a lens at the minimum (Figure 2). Any sound travelling at about 12° or less from the horizontal are unable to escape and are refracted back toward the minimum, allowing sound to propagate much further due to a reduction in spreading and reflection and adsorption by the sea surface and sea floor. This is known as the deep sound channel, or SOFAR channel. In the deep ocean at mid-latitudes, the slowest sound speed occurs at a depth of about 800 to 1000 meters. However, the depth varies from over 1600 m in the warmest waters of the world to100 m in colder waters and can even reach the surface at the ice edge, becoming a surface sound channel.

Finally, sound is often categorized as either signal or noise. However this categorization depends heavily on the receiver (listener), who will define sounds of interest as signals and everything else that might interfere with those signals as noise. For example, Navy sonar operators would consider their sonar to be a signal, while marine mammals are likely to consider it to be noise. Concerns regarding the impacts of noise on signals must also take into account differences in species and/or individuals range of hearing. The quietest sounds, across the range of frequencies that can be heard by an individual receiver define its hearing thresholds (Figure 3).

Anthropogenic Noise

Human use of the sea, such as for shipping, military activities, oil and gas exploration, and recreation (including cruises and pleasure boating), is increasing the amount of sound that is introduced into the oceans (see Table 1). As these sounds are generally not considered to be signals by marine fauna, they will be referred here as noise. The continuing increase in anthropogenic noise in the oceans may be affecting marine life in many ways, since many marine animals have evolved to use sound as their main means to communicate, sense their surroundings, and find food underwater (Berta, Sumich, & Kovacs, 2006). As light does not travel very far in water, auditory capabilities have evolved to supplement and/or replace the use of vision for many marine animals (Bradbury & Vehrencamp, 1998). The same advantages conferred by sound relative to light underwater have led humans to deliberately introduce sound into the ocean for many of the same reasons as marine fauna: communication (e.g., sub-to-sub), feeding (e.g., fish finding sonar) and navigation (e.g., depth-finders).

The sounds produced by the range of sources in Table 1 are also highly variable, some being characterized as impulsive (such as seismic surveys) and tonal (such as sonar), comparatively loud (such as explosives) and relatively quiet (such as most fishing activities), persistent (such as shipping), short (such as winches) and very short (such as a single seismic survey pulse). Some noise sources, such as explosions, naval low frequency active sonars (LFA), some mid-frequency active sonars, high-power seismic surveying systems that are used to explore the ocean floor for oil and natural gas resources and commercial ships can all be heard over large distances, sometimes across oceans (Nieukirk, Stafford, Mellinger, Dziak, & Fox, 2004).

In general, seismic survey airguns represent the most prolific impulsive sounds introduced into the ocean by human activity. Conversely, commercial shipping is collectively making an ever-increasing contribution to the omnipresent background noise over very large spatial scales in the ocean, as well as intermittent local impacts as point sources (see below).

Many of the various sources and their characteristics have been described in previous works (e.g., Hildebrand, 2005; Nowacek et al., 2007; NRC, 1994, 2003; Richardson et al., 1995). Therefore, here we shall focus on three source types that have drawn considerable recent attention: naval exercises, seismic surveys, and commercial shipping.

Naval Exercises and Sonar

Naval activities involve a number of activities that introduce noise into the oceans, including live-ammunition training, vessel noise and explosions. However, the exercises that have been subject to the most scrutiny are those involving mid-frequency sonar operations. Around the world, mid frequency sonars have been correlated with strandings of multiple Cuvier's beaked whales in the Bahamas and have been coincident in time and space with additional stranding incidents (see Brownell, Yamada, Mead, & van Helden, 2004; Cox et al., 2006; ICES, 2005;

Weilgart, this issue). Mid-frequency naval sonar can produce sound at levels of up to 237 dB re 1uPa @ 1m mainly at frequencies between 2-8 kHz on a 2-second duty cycle repeated as needed for variable periods. The two tactical sonars most frequently used by the US Navy, AN/SQS-53C and AN/SQS-56, are focused in the 2.6 to 3.3 and 6.8 to 8.2 kHz ranges, respectively. Approximately 145 of the US Navy's ~280 ships have mid-frequency sonar capabilities, although not all of these ships utilize these capabilities at any one time. However, the US Navy is not the only military using these or similar sonars and worldwide usage is unknown.

Table 1
Types of anthropogenic noise, with example sources. Note this is not an exhaustive list.

Noise	Example sources
Sonar	Military and commercial
Marine geophysical surveys	Commercial and research
Explosions	Military exercises and testing, dynamite fishing, offshore rig decommissioning
Acoustic deterrent devices (ADDs) and acoustic harassment devices (AHDs)	Fishing activities
Winches, onboard machinery, etc.	Fishing, research, commercial activity
Vessel noise at predominantly lower frequencies	Commercial shipping and other large vessel activity (e.g., tankers, military vessels, cruise liners, etc.)
Vessel noise at predominantly higher frequencies	Smaller commercial vessels (e.g., fishing, ferries, fast ferries, recreational boating, whale-watching and research vessels, etc.) and personal water craft (e.g., jet skis)
Ice breaking and associated engine noise	Icebreakers
Acoustic thermometry of the ocean climate (ATOC) and other sounds used for oceanographical studies	Research vessels and equipment
Noise from offshore development, both during construction and operation	Dredging and other development, (e.g., oil rigs, deep-water ports, wind farms, etc.)
Noise from coastal development (including on-ice activity) both during construction and operation	Ports and harbours, sea walls, piers, bridges, aquaculture facilities, industry and residential buildings
Aircraft (under the circumstances when sound crosses into the ocean)	Helicopters, aeroplanes (especially at supersonic speeds), spacecraft, missiles and other military projectiles
Traffic noise	Traffic on bridges and coastal roads, ice-trucking (through the ice)

Concerns were also raised regarding a surface towed low-frequency active sonar system (SURTASS-LFA) that can include up to 18 projectors in a vertical array, each producing pulses up to 215 dB re 1uPa @ 1m mostly between 100 and 500 Hz. This system utilizes the deep sound channel to propagate over very large distances. Several species of mysticetes use sounds with overlapping frequencies, and also appear to utilise the deep sound channel to increase the range of their sounds (Payne & Webb, 1971). Thus, environmental impact assessments for this sonar type have focused on changes in the feeding behaviors of blue and fin whales (*Balaenoptera musculus* and *B. physalu*; Clark & Altman, 2006; Croll, Clark, Calambokidis, Ellison, & Tershy, 2001), the migratory behaviour of grey whales

(*Eschrichtius robustus*; Tyack & Clark, 1988), and the reproductive behaviour of humpback whales (*Megaptera novaengliae*; Fristrup, Hatch, & Clark, 2003; Miller, Biassoni, Samuels, & Tyack, 2000). Although low-frequency active sonars are utilized much less frequently and by fewer Naval vessels than mid-frequency sonars (i.e., in the US Navy, only 2 ships are currently capable of deploying the SURTASS LFA system), due to the long-distance propagation capabilities of these systems, they may have more subtle impacts due to masking.

Seismic Surveys

Ships undertaking marine geophysical surveys tow seismic (airgun) arrays that emit loud sounds downward to probe under the sea bed for fossil fuels. Point-source intensity estimates for airguns are difficult due to the directional nature of the source, however arrays can produce levels equivalent to 260 dB re 1 µPa @ 1m (peak), with actual in-water pressure levels reaching maximums of approximately 235-240 dB. Although the sound is focused mainly downwards, some sound is emitted horizontally. Similarly, most of the energy is below 1,000 Hz with the predominant frequencies between 10-100 Hz, but there is considerable broadband energy, up to around 15 kHz or more, that is detectible, especially at relatively close range (Goold & Coates, 2006; Goold & Fish, 1998).

Airgun signals last around 40 ms, and are repeated every 7-20 s for several hours or days. Reflection and refraction can lengthen pulse durations (up to several seconds long) at the distance of the receiver. Although seismic surveying activity is concentrated in areas with extractable petroleum or natural gas (i.e., mostly on continental shelves, although this is changing as technology advances) the low frequency nature this source type means that the signal can travel for thousands of kilometers (Nieukirk et al., 2004).

Commercial Shipping

Noise from commercial ships is highly variable, but is generally produced at levels between 160 and 180 dB re 1uPa @ 1m (Richardson et al., 1995). Ships generate noise through their propellers, motors and gears. Noise from propellers comes from the many bubbles formed in the water by the rotating propeller blades. These bubbles quickly collapse or “cavitate” creating a loud acoustic sound. The faster the propeller rotates, the more cavitation noise. The breaking bubbles produce sound over a range of frequencies and, at high speeds, these frequencies can be as high as 40,000 Hz (Bartlett & Wilson, 2002; Wenz, 1962). However, propeller noise from large ships is usually concentrated below 200Hz. Low frequency noise generated by ships contributes significantly to the amount of low-frequency ambient noise in the ocean (Wenz, 1962). Because of the increase in propeller-driven vessels, low-frequency ambient noise has increased 10-15 dB, at an average of approximately 3 dB/decade over the past 50 years (Andrew, Howe, & Mercer, 2002; Cato & McCauley, 2002; Curtis, Howe, & Mercer, 1999; McDonald, Hildebrand, & Wiggins, 2006; Zakarauskas, Chapman, & Staal, 1990).

The spatial distribution of noise from shipping is non-uniform in the world’s oceans. In general, increases are more pronounced in the northern

hemisphere because of the higher shipping volumes involved (e.g., Cato, 1976; Cato & McCauley, 2002; McDonald, Hildebrand, & Wiggins, 2006). Also, the concentration of commercial traffic into shipping lanes and around ports tends to amplify vessel noise in these regions, although shallow water propagation on the continental shelf can reduce levels in some high traffic areas. Shipping noise is also directional as it moves away from the source, sometimes strongly so, thus altering the contribution of any single ship to the ambient noise depending on whether the measurement is made at the surface versus on the bottom and/or off the bow versus of the sides or stern (Gray & Greeley, 1980).

Contributions from commercial shipping are similarly variable temporally. For example, the number and size of ships entering the global maritime transport fleet continue to increase dramatically, with implications for noise due to both total input of noise and input per unit vessel. Short-sea shipping (short distance cargo hauling) is becoming more prevalent, with implications again due to additional coastal traffic. As the Arctic Ocean ice melts due to climate change, trans-Arctic paths become the best routes between Europe and both eastern Asia and western North America. Such changes are predicted to change the ambient noise profile of Arctic waters as well as introducing additional point-source noise to this area (Southall, 2005).

A Regional Case Study: The Gerry E. Studds Stellwagen Bank National Marine Sanctuary Passive Acoustic Monitoring Program

Underwater noise from ships can be evaluated at two spatial scales: as transient, relatively high intensity sounds at close range and as omnipresent, relatively low-intensity sound over great distances. The propagation efficiency of low-frequency shipping noise has led to concerns regarding possible “masking” of marine animal signals, particularly low frequency vocalizations, with possible negative effects including diminished abilities to find mates, maintain social structure, forage, navigate and/or evade predation (Erbe, 2002; Erbe & Farmer, 1998, 2000; Morisaka, Shinohara, Nakahara, & Akamatsu, 2005; Nowacek et al., 2007; Payne & Webb, 1971; Southall, Schusterman, & Kastak, 2000). Due to the long-distance propagation of shipping noise, evidence of such effects must be evaluated when animals are closely approached as well as over large spatial scales.

In 2004, the US National Oceanic and Atmospheric Administration (NOAA) Fisheries’ Ocean Acoustics Program further addressed this issue by sponsoring an international symposium on “Shipping Noise and Marine Mammals” (Southall, 2005). Symposium attendees found that prior to developing regulations and/or designing technology to mitigate shipping noise on marine mammals more research was necessary to determine the relative contributions made by identified sound sources to the total noise field. Such descriptive data gathering was also a central recommendation from an NRC (2003) report, which also stated the importance of characterizing temporal variation (e.g., annual, seasonal, monthly, and daily) and spatial variation when measuring sound fields. While the NRC Committee and the NOAA Symposium were focused globally, many of their resultant insights and recommendations can be applied at a smaller “case-study” scale to provide a more local understanding of the noise-marine

mammal issue. Insights achieved from case studies can then be used to inform the issue on national and international scales.

Such a case study is being developed within the Gerry E. Studds Stellwagen Bank National Marine Sanctuary (SBNMS or sanctuary), where collaborators are generating methodologies to merge data from passive acoustic monitoring devices with vessel tracking systems and to identify the contributions made by various classes of noise (Hatch et al., in review). The SBNMS is an "urban" marine sanctuary located to the east of Boston, Massachusetts, U.S.A. in close proximity to a densely populated coastal zone (Figure 4).

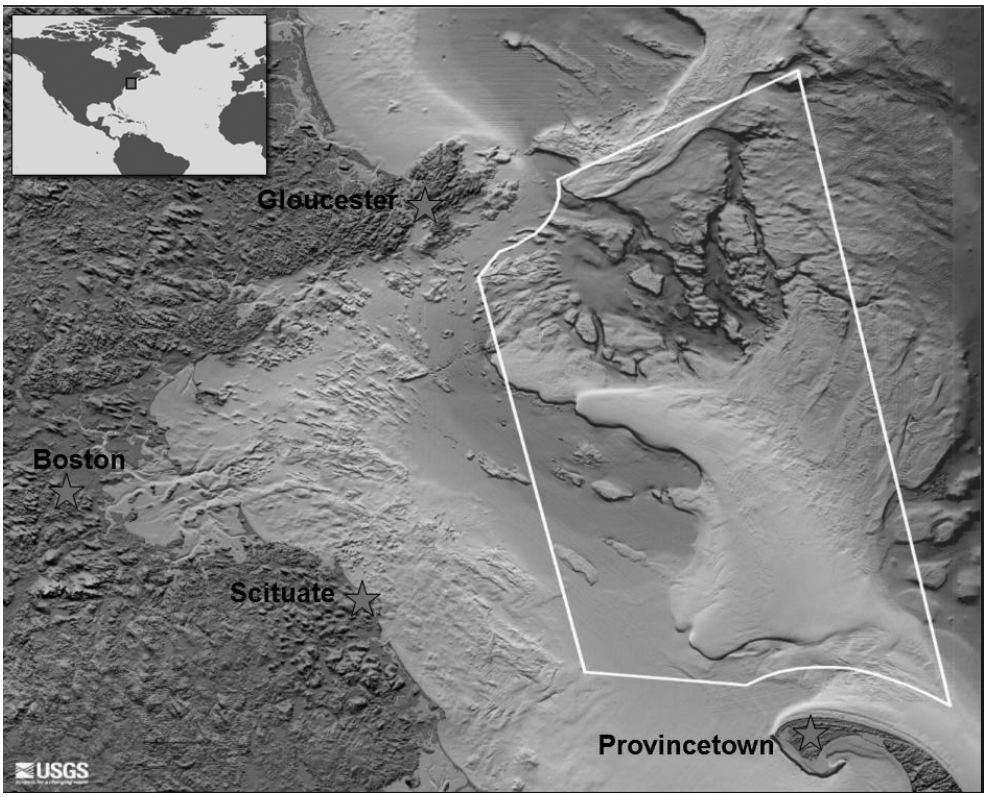


Figure 4. Location, boundaries and bathymetry of the Gerry E. Studds Stellwagen Bank National Marine Sanctuary in Massachusetts Bay off the northeast coast of the United States.

Stellwagen Bank, the central feature of the sanctuary, is home to some of the oldest and highest capacity commercial fisheries in the world and is an important feeding ground for endangered marine mammals such as the North Atlantic right whale (*Eubalaena glacialis*), humpback whale and fin whale. Because the Boston Traffic Separation Scheme (TSS) (the United Nations International Maritime Organization's recommended route for commercial vessels en route to and departing the Port of Boston) transits the sanctuary, these vulnerable marine species are at high risk of collisions with vessels and exposure to shipping noise.

Beginning in January 2005, a collaborative research team comprised of SBNMS, NOAA Fisheries' Northeast Fisheries Science Center, and Cornell

University's Bioacoustics Research Program deployed nine-ten autonomous recording units (ARUs) (Calupca, Fristrup, & Clark, 2000) to monitor the low frequency (10-1000Hz) acoustic environment of the SBNMS. Through additional collaboration with the US Coast Guard's Research and Development Center, data from four Automatic Identification System (AIS) receivers have been used to track all large commercial traffic transiting Massachusetts Bay and surrounding waters. Under the International Maritime Organization (IMO)'s current mandates, all ocean-going commercial traffic over 300 gross tons or carrying over 165 passengers, as well as all tugs and tows, are required to carry Automatic Identification System (AIS) transmitters (Federal Register, 2003; IALA, 2004). Shipboard AIS transponders transmit a vessel's position, identity and other characteristics (including but not limited to length, beam, draught, cargo type, destination and speed) as often as every two seconds.

AIS data are extracted by the SBNMS and the University of New Hampshire's Center for Coastal and Ocean Mapping using custom software written in Python (Python Software Foundation, 2007) added to the NOAA package (Schwehr, 2007). Analyses are then conducted to describe the abundance, behaviour and distribution of different vessel types over various spatial and temporal scales. Analysis of received levels at each ARU are used to compare the low frequency intensities of highly trafficked versus less highly trafficked locations of the sanctuary. Variations in received levels are then correlated with variations in vessel abundance, distribution and/or behaviour. Future research will continue to quantify the relative contribution of noise per vessel type to the sampling region's total "noise budget" (NRC, 2003). These analyses, together with synchronous year-long analyses of vocal behaviours of several endangered whale species in the SBNMS, will be used to inform management of sanctuary resources and initiate sanctuary ocean noise policy. For example, better understanding the large-scale and long-term behaviour of vessels and their acoustic footprints is currently aiding the SBNMS to quantify acoustic benefits to whales due to the recent shifting and narrowing of the Boston Traffic Separation Scheme (IMO, 2006).

Summary

Although descriptive data, including time-series data from longer-term monitoring efforts, continue to be collected and analyzed, it is clear that noise from numerous anthropogenic sources is both extensively and increasingly present within the marine environment. Technological innovation and climate change are allowing human activities to leave both deeper and larger acoustic "footprints" in the world's oceans. In response to increased accessibility and/or the growing use of remote sensing capabilities, new acoustic signals continue to be designed to address commercial, research and defense needs. In addition to purposeful use of acoustic sources, incidental noise from coastal development and vessel traffic are exposing greater proportions of marine life to increasing levels of noise. The vast majority of human-produced sources of underwater noise have intensified over a very short timeframe in evolutionary terms, providing only a few generations (at most) for species to adapt.

Experts agree that a better understanding of the relative contributors to the total ocean noise in areas of concern is needed. With its high concentrations of both acoustically-active endangered species and human activities that produce noise, Stellwagen Bank National Marine Sanctuary represents a perfect test-bed for both characterizing noise inputs and examining their impacts on marine life. Results from this highly collaborative research effort will be used to assist government agencies in fulfilling their responsibilities to identify, implement and monitor means of balancing the protective needs of marine species and ecosystems with the commercial, recreational, research and defensive needs of humans.

References

Andrew, R. K., Howe, B. M. & Mercer, J. A. (2002). Ocean ambient sound: comparing the 1960s with the 1990s for a receiver off the California coast. *Acoustics Research Letters Online*, **3**, 65-70.

Bartlett, M. L. & Wilson, G. R. (2002). Characteristics of small boat signatures (Abstract only). *Journal of the Acoustical Society of America*, **112**(5), 2221.

Berta, A., Sumich, J. L. & Kovacs, K. M. (2006). *Marine Mammals Evolutionary Biology* (2nd ed.). Burlington, MA: Elsevier Inc.

Bradbury, J. W. & Vehrencamp, S. L. (1998). *Principles of Animal Communication*. Sunderland, MA: Sinauer Associates, Inc.

Brownell, Jr., R. L., Yamada, T., Mead, J. G. & van Helden, A. L. (2004). *Mass Strandings of Cuvier's Beaked Whales in Japan: U.S. Naval Acoustic Link?* Paper SC56/E37 presented to the Scientific Committee at the 56th Meeting of the International Whaling Commission, 29 June - 10 July 2004, Sorrento, Italy. (Unpublished. Available from the Office of the Journal of Cetacean Research and Management).

Calupca, T. A., Fristrup, K. M. & Clark, C. W. (2000). A compact digital recording system for autonomous bioacoustic monitoring (Abstract only). *Journal Acoustical Society of America*, **108**(5), 2582.

Cato, D. H. (1976). Ambient sea noise in waters near Australia. *Journal of the Acoustical Society of America*, **60**(2), 320-328.

Clark, C. W. & Altman, N. S. (2006). Acoustic detections of blue whale (*Balaenoptera musculus*) and fin whale (*B. physalus*) sounds during a SURTASS LFA exercise. *IEEE Journal of Oceanic Engineering*, **31**(1), 120-128.

Cato, D. H. & McCauley, R. D. (2002). Australian research in ambient noise. *Acoustic Australia*, **30**, 13-20.

Cox, T. M., Ragen, T. J., Read, A. J., Vos, E., Baird, R. W., Balcomb, K., Barlow, J., Caldwell, J., Cranford, T., Crum, L., D'Amico, A., D'Spain, G., Fernández, A., Finneran, J., Gentry, R., Gerth, W., Gulland, F., Hildebrand, J., Houser, D., Hullar, T., Jepson, P. D., Ketten, D., MacLeod, C. D., Miller, P., Moore, S., Mountain, D., Palka, D., Ponganis, P., Rommel, S., Rowles, T., Taylor, B., Tyack, P., Wartzok, D., Gisiner, R., Mead, J. & Benner, L. (2006). Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management*, **7**(3), 177-187

Croll, D. A., Clark, C. W., Calambokidis, J., Ellison, W. T. & Tershy, B. R. (2001). Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. *Animal Conservation*, **4**, 13-27.

Curtis, K. R., Howe, B. M. & Mercer, J. A. (1999). Low-frequency ambient sound in the North Pacific: long time series observations. *Journal of the Acoustical Society of America*, **106**, 3189-3200.

Discovery of Sound in the Sea (a). *Science of Sound in the Sea: Sound*. Retrieved 2 August 2007 from http://www.dosits.org/science/whatis/frequency.htm.

Discovery of Sound in the Sea (b). *Science of Sound in the Sea: Sound Movement*. Retrieved 2 August 2007 from http://www.dosits.org/science/sndmoves/4.htm.

Discovery of Sound in the Sea (c). *Animals and Sound in the Sea: Effects of Sound*. Retrieved 2 August 2007 from http://www.dosits.org/animals/effects/e2a.htm.

Erbe, C. (2002). Underwater noise of whale-watching boats and potential effects on killer whales (*Orcinus orca*), based on an acoustic impact model. *Marine Mammal Science*, **18**(2), 394-418.

Erbe, C. & Farmer, D. M. (2000). Zones of impact around icebreakers affecting beluga whales in the Beaufort Sea. *Journal Acoustical Society of America*, **108**, 1332-1340.

Erbe, C. & Farmer, D. M. (1998). Masked hearing thresholds of a beluga whale (*Delphinapterus leucas*) in icebreaker noise. *Deep Sea Research*, **45**, 1373-1387.

Federal Register. (2003). Automatic Identification System; Vessel Carriage Requirement. *U.S. Federal Register*. **68**(204), 60559-60570.

Fristrup, K. M., Hatch, L. T. & Clark, C. W. (2003). Variation in humpack whale (*Megaptera novaengliae*) song length in relation to low-frequency sound broadcasts. *Journal of the Acoustical Society of America*, **113**, 3411-3424.

Goold, J. C. & Coates, R. F. W. (2006). *Near Source, High Frequency Air-Gun Signatures*. Paper SC/58/E30 presented to the International Whaling Commission Seismic Workshop, 24-25 May 2006, St. Kitts. (Unpublished. Available from the Office of the Journal of Cetacean Research and Management).

Goold, J. C. & Fish, P. J. (1998). Broadband spectra of seismic survey airgun emissions, with reference to dolphin auditory thresholds. *Journal of the Acoustical Society of America*, **103**(4), 2177-2184.

Gray, L. M. & Greeley, D. S. (1980). Source level model for propeller blade rate radiation for the world's merchant fleet. *Journal Acoustical Society of America*, **67**(2), 516-522.

Hatch, L. T., Clark, C. W., Merrick, R., Van Parijs, S., Ponirakis, D., Schwehr, K., Thompson, M. & Wiley, D. (in review). Characterizing the relative contributions of large vessels to total ocean noise fields: a case study using the Gerry E. Studds Stellwagen Bank National Marine Sanctuary. *Environmental Management*.

Hildebrand, J. A. (2005). Impacts of anthropogenic sound. In J. E. Reynolds, III, W. F. Perrin, R. R. Reeves, S. Montgomery, & T. J. Ragen (Eds.), *Marine Mammal Research: Conservation Beyond Crisis* (pp. 101-124). Baltimore: Johns Hopkins University Press.

IALA – International Association of Marine Aids to Navigation and Lighthouse Authorities. (2004). *IALA Guideline No. 1028 On The Automatic Identification (AIS): Part I Operational Issues* (1.3 ed.). Saint Germain en Laye, France: IALA. 131 pp. Available at: http://www.navcen.uscg.gov/enav/ais/IALA_AIS_Guidelines_Vol1_Pt1%20OPS%20(1.3).pdf.

ICES – International Council for the Exploration of the Sea (2005). *Report of the Ad-hoc Group on the Impact of Sonar on Cetaceans and Fish* (AGISC) (2nd ed.). CM 2006/ACE. Denmark: ICES. IMO – International Maritime Organization (2006). *New and Amended Existing Traffic Separation Schemes*. Maritime Safety Committee COLREG.2/Circ.58, Ref. T2-OSS/2.7.1. London: IMO.

Madsen, P. T. (2005). Marine mammals and noise: Problems with root mean square sound pressure levels for transients. *Journal of the Acoustical Society of America*, **117**(6), 3952-3957.

McDonald, M. A., Hildebrand, J. A. & Wiggins, S. M. (2006). Increases in deep ocean ambient noise in the Northeast Pacific west of San Nicolas Island, California. *Journal Acoustical Society of America*, **120**(2), 711-718.

Miller, P. J. O., Biassoni, N., Samuels, A. & Tyack, P. L. (2000). Whale songs lengthen in response to sonar. Nature, **405**, 903.

MMC – U.S. Marine Mammal Commission (2007). *Marine Mammals and Noise: A Sound Approach to Research and Management*. A Report to the US Congress from the Marine Mammal Commission. Bethesda, MD: U.S. Marine Mammal Commission.

Morisaka, T., Shinohara, M., Nakahara, F. & Akamatsu, T. (2005). Effects of ambient noise on the whistles of Indo-Pacific bottlenose dolphin populations. *Journal of Mammalogy*, **86**(3), 541-546.

Munk, W., Worcester, P. & Wunsch, C. (1995). *Ocean Acoustic Tomography*. New York, NY: Cambridge University Press.

Nieukirk, S.L., Stafford, K.M., Mellinger, D.K., Dziak, R.P. & Fox, C.G. (2004). Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean. *Journal of Acoustical Society of America*, **115**(4), 1832-1843.

Nowacek, D. P., Thorne, L. H., Johnston, D. W. & Tyack, P. L. (2007). Responses of cetaceans to anthropogenic noise. *Mammalian Review*, **37**(2), 81-115.

NRC – U.S. National Research Council (2003). *Ocean Noise and Marine Mammals*. Washington, DC: National Academy Press.

NRC – U.S. National Research Council (1994). *Low-Frequency Sound and Marine Mammals: Current Knowledge and Research Needs*. Washington, DC: National Academy Press.

Payne, R. & Webb, D. (1971). Orientation by means of long range acoustic signaling in baleen whales. *Annals of the New York Academy of Sciences*, **188**, 110-141.

Python Software Foundation. (2007). Python. v2.5.1.

Richardson, W. J., Greene, Jr., C. R., Malme, C. I. & Thomson, D. H. (1995). *Marine Mammals and Noise*. San Diego, CA: Academic Press, 576 pp.

Schwehr, K. (2007). noaadata - Python software for processing AIS and water level data. v0.29. Durham, NH. Available from: http://vislab-ccom.unh.edu/~schwehr/software/noaadata.

Southall, B. L. (2005). *Shipping Noise and Marine Mammals: A Forum for Science, Management, and Technology*. Final Report of the National Oceanic and Atmospheric Administration (NOAA) International Symposium 18-19 May 2004, Arlington, Virginia, U.S.A. Silver Spring, MD: NOAA Fisheries Acoustics Program.

Southall, B. L., Schusterman, R. J. & Kastak, D. (2000). Masking in three pinnipeds: underwater, low-frequency critical thresholds. *Journal Acoustical Society of America*, **108**(3), 1322-1326.

Tyack, P.L., & C.W. Clark. (1998). *Quick-Look Report: Playback of Low-Frequency Sound to Gray Whales Migrating Past the Central California Coast*. Unpublished. - January, 1998.

Urick, R.J. (1983). *Principles of Underwater Sound* (3rd ed.). New York: McGraw-Hill, Inc.

Weilgart, L. S. (2007). A brief review of known effects of noise on marine mammals. *International Journal of Comparative Psychology*, **this issue**, 159-168.

Wenz, G. M. (1962). Acoustic ambient noise in the ocean: Spectra and sources. *Journal of the Acoustical Society of America*, **34**, 1936-1956.

Zakarauskas, P., Chapman, D.M.F. & Staal, P.R. (1990). Underwater acoustic ambient noise levels on the eastern Canadian continental shelf. *Journal of the Acoustical Society of America*, **87**(5), 2064-2071.

International Journal of Comparative Psychology, 2007, **20**, 134-144.
Copyright 2007 by the International Society for Comparative Psychology

Effects of Noise on Rodent Physiology

Ann Linda Baldwin
University of Arizona, U.S.A.

Experiments are described in which Sprague Dawley rats were deliberately subjected to a daily 15-min white noise regime (90 dB) for 3 or 6 weeks, to determine its effects on the cardiovascular system and intestinal mucosa. In one set of experiments cardiovascular responses were monitored by radiotelemetry. Exposure to noise increased heart rate and mean arterial pressure and reduced stimulation of the parasympathetic nervous system. In the second set of experiments, one group of rats was exposed to the noise protocol for 3 weeks and a second group was not. All the rats were then anaesthetized and the small intestines of half the animals were fixed for microscopy. The remaining rats had their mesenteric microvasculature perfused for one minute with fluorescent albumin before fixing for microscopy. The rats exposed to noise showed significantly more eosinophils and degranulated mast cells in the intestinal villi than the quiet rats. In addition, the villi were swollen and the epithelial cells had widened junctions. The noise group also showed significantly more leakage of fluorescent albumin from the mesenteric microvessels. These experiments demonstrate that 90 dB white noise reduces stimulation the parasympathetic nervous system and also induces an inflammatory response in the intestinal mucosa, resulting in structural damage. These results are consistent with a stress response.

Several studies have shown that noise in animal care facilities can reach as high as 90 – 100 dB (Pfaff & Stecker, 1976; Milligan, Sales & Khirnykh, 1993). Such levels of noise can induce physiological and behavioral responses in laboratory rodents such as increased plasma corticosterone levels, reduction in body weight, decrease in gastric secretion, changes in immune response and tumor resistance, and a decrease in reproductive function. Behavioral responses include increases in total activity, grooming themselves and their cage-mates, and rearing onto their hind legs (Clough, 1982; Gamble, 1982; Sales, Wilson, Spencer, & Milligan, 1988; Milligan et al., 1993, Baldwin, Primeau, & Johnson, 2006). These changes are similar to those seen in rodents exposed to other stressful situations (Sharp, Azar, & Lawson, 2003). In spite of the evidence that noise levels in animal facilities are often high enough to produce uncontrolled physiological and psychological responses, the acoustic levels continue to be not as monitored as other environmental factors (lighting, temperature, humidity, etc).

Although noise has deleterious effects on rodent physiology, little is known about how the autonomic nervous system (ANS) is affected. Such information would indicate the state of emotional stress of the animals (Cerutti, Bianchi, & Mainardi, 1995). It is essential that the stress status of laboratory animals is monitored and controlled because stress may alter the experimental data obtained from those animals (Poole, 1997). One way of recording changes in the ANS is to measure the beat-to-beat changes in heart rate (i.e. heart rate variability, HRV). The variability is due to the changes in the activity of the sympathetic and

Correspondence concerning this article should be addressed to Ann Baldwin, Department of Physiology, College of Medicine, University of Arizona, Tucson, AZ 85724-5051, U.S.A. (abaldwin@u.arizona.edu).

parasympathetic nerves of the ANS, resulting in an alteration of sympathovagal balance. Acute social and psychological stressors affect the ANS by increasing sympathetic activation and decreasing parasympathetic activation, and these actions are reflected in changes in HRV. This article describes experiments in which groups of rats were exposed daily to a 15-min white noise regime (90 dB) for three weeks, to determine the effects of noise on the ANS (Burwell & Baldwin, 2006). Since stress responses can exert their influence by affecting ANS and endocrine output to the viscera (Mayer, Naliboff,, & Chang, 2001) further studies are described (Baldwin et al., 2006; Baldwin & Bell, 2007), in which a similar noise protocol was used to determine effects of noise on the integrity of the intestinal mucosa and mesenteric microvessels. The experimental methods are fully described in the publications cited above and just are outlined briefly here.

Method

Effects of Noise on ANS

Animals. Six male Sprague Dawley rats weighing 375 – 400 g were obtained from Charles River Laboratories (Portage, MI). Three of the rats were implanted at Charles River with PhysioTel® C50-PXT telemetry transmitters (Data Sciences International (DSI), St. Paul, MN), allowed to recover and shipped to Tucson, AZ. Upon arrival, each implanted rat was pair-housed with a non-implanted rat. No data were collected from the non-implanted rats; they served only as cage-mates for the implanted rats. Lights were on from 06:00 until 18:00. All research procedures and animal care were reviewed and overseen by the University of Arizona's institutional animal care and use committee (IACUC).

Experimental Protocol. The same animals were used throughout the experiments and were subjected to 3 or 6 weeks of daily noise, separated by 3 weeks of quiet time. The white noise stimulus consisted of a combination of frequencies from 10 Hz to 10 kHz that were electronically generated and recorded onto a CD in a 15-minute segment played between 8:00 and 8:15 each morning. The total SPL of the white noise in the animal room was 90 dB as compared with the background noise of 50 dB. On three mornings per week, telemetry data were collected before (07:50 – 08:00), during (08:00 – 08:15) and after (08:15 – 08:25) delivery of the noise. During quiet (control) periods, no stimulus was delivered and telemetry data were collected for 15 minutes sometime between 07:50 and 08:25. For three nights per week, when the rats were in their active phase, during noise experiments and quiet periods, telemetry data were collected for 15 minutes sometime between 20:00 and 21:00. Three distinct frequency ranges were identified in the power spectrum of the data: very low frequency (VLF, 0.05 – 0.25 Hz), low frequency (LF, 0.25 – 1.00 Hz), and high frequency (HF, 1.00 – 3.00 Hz). Spectral analysis of HRV in times of emotional stress shows an increase in LF power, a decrease in HF power, and an increase in the LF/HF ratio.

Statistical Analysis. Data were compared under different conditions, within the same animal and during the same observation period, using the paired Student t-test, with $p < 0.05$ considered to be statistically significant, after checking that the data passed the tests for normality and equal variance. All data are presented as mean ± standard error of the mean (SEM).

Effects of Noise on Intestinal Mucosa and Microvascular Leakage

Animals. Male Sprague Dawley rats were housed in pairs in cages as described previously (Burwell & Baldwin, 2006) in two separate identical rooms. The one intentional difference between the environments in the two rooms was that the rats in one of the rooms received a white noise stimulus (90 dB) for 15 minutes each day at the same time every day, for 3 weeks, just before the lights were switched off at 18:00. These rats are referred to as 'noise' rats. The rats in the other room

('quiet' rats) did not receive the white noise stimulus. Both rooms were chosen so that they were remote from noise-producing equipment, such as cage washers. Apart from the investigator, the animal care technician was the only person who entered the rooms. Background noise in these rooms did not exceed 50 dB. A third group of rats were housed in the 'noise' room for 3 weeks and then moved to the 'quiet' room for a further 3 weeks to determine whether noise-induced effects on the intestinal mucosa could be reversed. These rats are referred to as 'recovery' rats.

Experimental Protocol. After three weeks the animals were anesthetized for surgery (Baldwin, Primeau, & Johnson, 2006). Half of the animals from each room had their intestinal ileum prepared for light and electron microscopy in order to evaluate degranulation of mucosal mast cells, migration of eosinophils from the blood into the lamina propria, mean width of villus lamina propria and integrity of the mucosal epithelium (8 rats per group). To prepare the ileum for microscopy, the portal vein was incised for use as a flow outlet and the intestinal microvasculature was perfused at physiological pressure with physiologically-buffered Karnovsky fixative. After one hour, an 8 cm segment from the ileum was excised and fixed for one more hour. The segment was then divided into 4 portions that were incubated in 2% diaminobenzidine, post-fixed in osmium tetroxide, dehydrated and embedded in Spurrs' resin. The tissue was thick-sectioned for light microscopy and stained with 1% toluidine blue; it was also thin-sectioned for electron microscopy and stained with uranyl acetate and lead citrate. Thick sections were observed using an Axioplan microscope (Zeiss, Germany) equipped with 20x (numerical aperture 0.6) and 40x (numerical aperture 0.75; water immersion) Zeiss objectives. Thin sections were observed for electron microscopy using a model CM12 Phillips electron microscope (FEI Company, Tacoma WA).

In later experiments the presence of reactive oxygen species (ROS) was monitored in 'noise' and in 'quiet' rats by exposing a small segment of mucosa and suffusing it with dihydrorhodamine (DHR) 123 under epi-fluorescence microscopy. Niu et al. (1996) have shown that superoxide can be detected in the tissue using DHR which only fluoresces when in contact with ROS, specifically hydrogen peroxide-derived oxidants, and intra-vital digital micro-fluorography allows for quantification of oxidant production.

For the remaining animals (6 rats per group) the superior mesenteric artery was cannulated, the animals euthanized (Baldwin & Bell, 2007) and the mesenteric microcirculation was perfused for one minute with fluorescent albumin followed by fixative. The mesenteric tissue was then observed under epi-fluorescence microscopy to determine the mean number and area of leakage spots of fluorescent albumin per unit length of venule. In later experiments some of these rats were fed a special diet with increased concentrations of the antioxidants, vitamin E (10,000 IU/kg diet) and α-lipoic acid (1.65g/kg diet).

Statistical Analysis. For each parameter the Kruskal-Wallis test was applied for comparing different animals within the same group, and the Mann-Whitney Rank Sum test for comparing pairs of groups. The n was taken as the number of rats in a group and a p-value < 0.05 indicated significance.

Results

Effects of Noise on ANS

In response to white noise all 3 rats showed significant increases in HR and MAP (8% and 15%, respectively), compared to before the stimulus, and these parameters stayed elevated during the 10 minutes after the stimulus. No consistent or significant patterns were observed regarding the sympathetic nervous system (power of the LF range) in any of the rats in response to the white noise. However, an attenuation (12-13%) of the parasympathetic nervous system (power of the HF range) during and/or after the white noise was observed in all rats. Corresponding shifts in the sympathovagal balance (LF/HF ratio) were also observed during and after the white noise compared to before the stimulus. The increases in the LF/HF

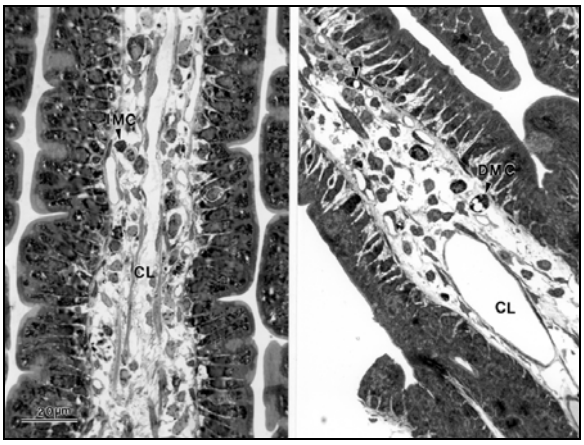
ratio were often small because the sympathetic nervous system remained relatively unchanged as the parasympathetic nervous system was attenuated.

Effects of Noise Stress on the Structure of the Intestinal Mucosa

Overall Appearance. Upon visual inspection, the small intestine of the 'noise' rats was noticeably more swollen and inflamed (hyperaemic) than seen in the 'quiet' rats. In addition, the Peyers' patches along the whole length of the jejunum and ileum were more swollen, suggesting increased activation of the immune system.

Light Microscopy. Longitudinally cut thick sections of parts of villi from a 'quiet' rat and a 'noise' rat are shown in Figures 1a and 1b, respectively. An intact mast cell (IMC), identified by its stained granules, in the lamina propria and adjacent to the central lacteal (CL) can be seen in Figure 1a. Degranulated mast cells (DMC) in the lamina propria can be seen in Figure 1b. There were significantly more degranulated mast cells per villus cross-section in the 10 villi closest to each edge of each Peyers' patch examined in 'noise' rats than in 'quiet' rats (3.95 ± 0.80 (SEM), 60 villi versus 0.35 ± 0.29, 80 villi). The Kruskal-Wallis test demonstrated that there was much greater variance between groups ($p<0.001$) than within groups ($p = 0.06$). 'Recovery' rats did not show a significant reduction in the number of degranulated mast cells, compared to the 'noise' rats (2.37 ± 0.83, 115). Similar results with degranulated mast cells were obtained when the 'noise' and 'quiet' rooms were reversed. Villi near Peyers' patches showed 2.77 ± 0.72 and 0.39 ± 0.48 for 'noise' rats and 'quiet' rats respectively. A one-way blocked ANOVA test demonstrated a significant difference between 'noise' and 'quiet' groups, but not between rooms, *per se* indicating that the data were not confounded by intrinsic differences between the rooms themselves. In villi near Peyers' patches significantly more eosinophils per villus section could be seen in the lamina propria of 'noise' rats than of "quiet" rats (9.46 ± 0.44, 60 villi versus 4.58 ± 0.38, 60 villi.)

Overall, the intestinal villi from 'noise' rats were significantly more edematous than those from 'quiet' rats, as assessed by measurements of villus lamina propria width using light microscopy. The mean villus widths of the 'noise', 'quiet' and 'recovery' groups were 57.0 ± 0.9, 39.0 ± 0.7 and 59.0 ± 0.7 μm, respectively (4 animals/group, 40 villi /animal). The distended central lymphatic vessels in villi from 'noise' rats (compare CL in Figures 1a and 1b) and the greater area of cell-free tissue indicate that the increased width of the villus lamina propria was produced by edema, rather than by increased cell growth. The villi of the 'recovery' group were just as edematous as those from the 'noise' group, consistent with the finding that the number of degranulated mast cells also remained high in this group.



a. **b.**

Figure 1. Light micrographs of longitudinally cut thick sections of parts of villi from a "quiet" rat (a) and a "noise" rat (b). The sections were stained with toluidine blue. See enlarged central lacteal (CL) in (B). Scale bar: 20 µm.

Electron Microscopy. Representative photomicrographs of the mucosal epithelium from the three groups of rats are shown in Figures 2a-c. Figure 2a demonstrates that in 'quiet' rats, the epithelial cells (E) were generally attached to each other and to the basement membrane. Very few eosinophils were evident. 'Noise' room rats, on the other hand, (Figure 2b), usually demonstrated large numbers of epithelial cells that were separating from each other and, in places, were separated from the basement membrane. Epithelial cells were considered to be separated from each other if a distinct gap could be seen between adjacent cells which extended in length from the basement membrane to the top of the cell nuclei (nearest the epithelial surface microvilli). Epithelial cells were considered to be separated from the basement if a gap appeared between the main body of the cell and the remnants of the cell adhering to the basement membrane.

Many intestinal villi contained eosinophils (EO) and partially degranulated mast cells (MC). In figure 2b an inter-epithelial leukocyte (IEL) and capillary (C) are also visible. Three weeks in the quiet room, following 3 weeks in the noise room, produced some epithelial repair (Figure 2c). Although the epithelial cells were still somewhat separated from each other, and extended long, tenuous cytoplasmic projections from their junctional aspects, the cells were rarely separated from the basement membrane.

Presence of Reactive Oxygen Species in Intestinal Mucosa

Significantly more intense DHR fluorescence was seen in the villus epithelium of 'noise' rats (58 ± 10 (SD), arbitrary units, 9 rats, 93 villi), compared to 'quiet' rats (35 ± 13, 3 rats, 55 villi), and fluorescent granules appeared in the lamina propria of 'noise' rats. These results imply that the noise-induced mucosal damage was oxidative in nature

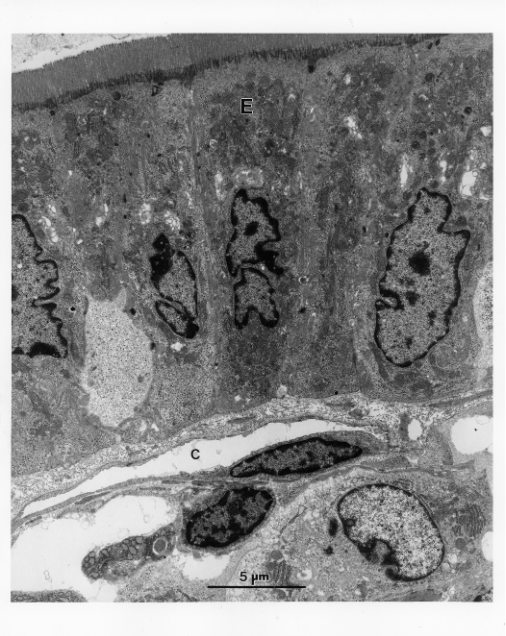


Figure 2a. Demonstrates that in "quiet" rats, the epithelial cells (E) were generally attached to each other and to the basement membrane. Very few eosinophils were evident.

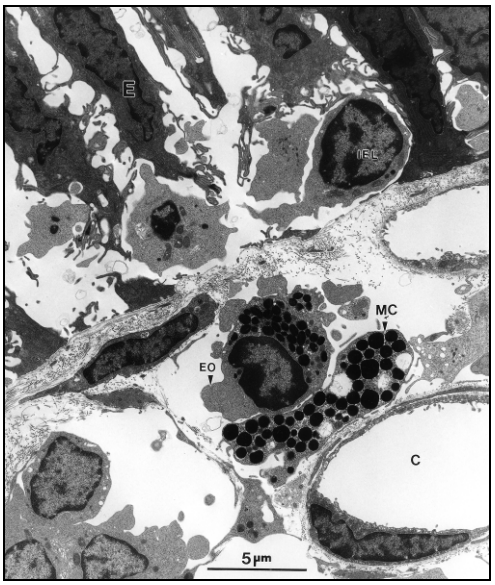


Figure 2b. "Noise" room rats usually demonstrated large numbers of epithelial cells that were separating from each other and, in places, were separated from the basement. Many intestinal villi contained eosinophils (EO) and partially degranulated mast cells (MC). In this figure an interepithelial leukocyte (IEL) and capillary (C) are also visible.

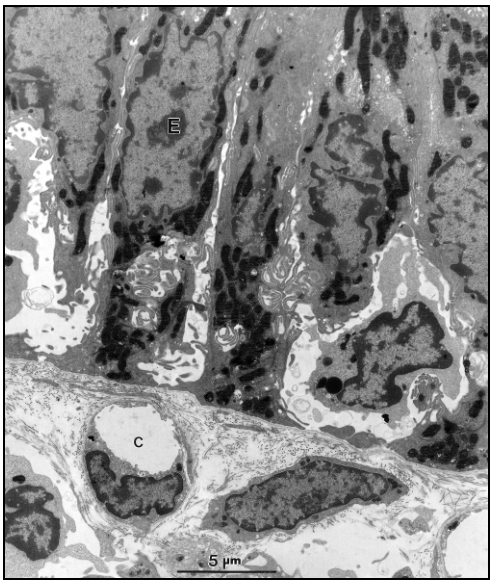


Figure 2c. Shows that three weeks in the quiet room, after 3 weeks in the noise room, resulted in some epithelial repair. Scale bars: 5 µm.

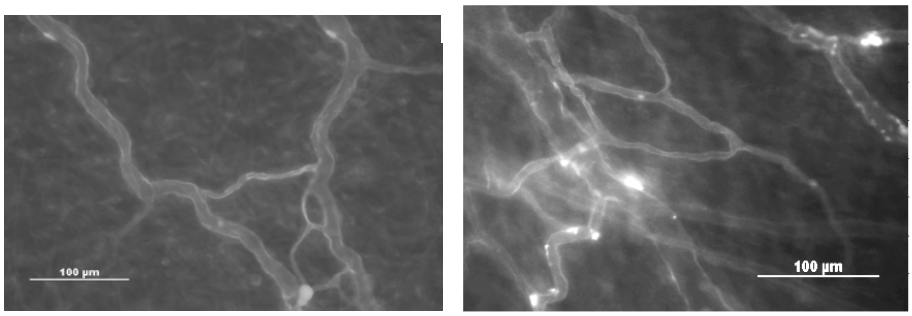
Effects of Noise Stress on Microvascular Leakage

Rats from the noise group (n=9) demonstrated significantly more leakage sites (3.84 ± 0.46 (SEM) x 10^{-3} μ^{-1}, n=95 venules) and a significantly greater leakage area per length of venule (3.20 ± 0.49 μ^2/μ), than rats from the quiet group (n=10) (1.38 ± 0.26 (SEM) x 10^{-3} $\mu^{-1}$and 0.30 ± 0.06 μ^2/μ, respectively, n=123 venules) or the recovery group (n=6) (1.40 ± 0.24 (SEM) x 10^{-3} μ^{-1} and 0.63 ± 0.16 μ^2/μ, respectively, n=108 venules). Rats from the recovery and quiet groups showed similar numbers of leaks per length of venule, but the recovery group demonstrated significantly greater leak area per venule length than the quiet group, although still significantly less than for the noise group . The percentages of venules observed that contained leaks in the noise, quiet and recovery groups were 73%, 37% and 39%, respectively. Light micrographs of typical microvascular networks from a quiet group rat and a noise group rat, after perfusion with FITC-albumin, are shown in figures 3a and 3b. Extensive fluorescent leaks are visible in the network from the noise group rat but few leaks can be seen in the network from the quiet group rat.

Mast Cell Degranulation

The mean number of degranulated mast cells per microscopic field of view (1.13 mm^2) was significantly greater for the noise group (13.75 ± 0.77) and the recovery group (12.09 ± 0.90) than for the quiet group (7.43 ± 0.36). These results

indicate that daily noise markedly increases microvascular permeability in rats, and that this change may be stimulated by mast cell degranulation.



a. **b**.

Figure 3. Light micrographs of mesenteric microvascular networks after perfusion with fluorescent (FITC)-labeled albumin. (a) Network from an animal that had not been exposed to daily noise. No leaks can be seen. (b) Network from an animal that had been exposed to daily noise. Many leaks of FITC-albumin from the venules are visible. Scale bars: 100 µm.

Antioxidants and Microvascular Leaks

Vitamin E with α-lipoic acid significantly reduced noise-induced venular leakage to fluorescent albumin although not to control levels. The quiet control animals (n=6) had a mean number of leaks per micron length of venule of 0.44 ± 0.06 (SEM) x 10^{-2} μ^{-1}, (n= 341 venules), compared to 3.05 ± 0.32 (SEM) x 10^{-2} μ^{-1}, (n= 294 venules, n=6 rats) for noise alone, and 1.04 ± 0.19 (SEM) x 10^{-2} μ^{-1}, (n= 304 venules, n=6 rats), for noise and vitamin E with α-lipoic acid. The results for leak area per micron length of venule were similar, corresponding values being 0.44 ± 0.10 (SEM) $\mu^2\mu^{-1}$, 6.60 ± 0.88 (SEM), 1.90 ± 0.51(SEM) and 2.33 ± 0.29 (SEM). Thus leak number was significantly reduced by about 66% with vitamin E and α-lipoic acid. Leak area was reduced even more, by 70% with vitamin E and α-lipoic acid.

Discussion

Exposure of rats to 90 dB white noise every day increases both HR and MAP when recorded during, and immediately after, the noise. It could be argued that the increases in HR and MAP produced by noise could have been caused by increased activity rather than by a stress response. However, that is unlikely in these experiments because apart from a startle response, lasting a second or so on the first day of the noise, very little activity was observed at this time. Thus the increased cardiovascular parameters were caused by a stress response. In this study we show that a decrease in the activation of the parasympathetic nervous system is responsible for the cardiovascular response, rather than an increased activity of the sympathetic autonomic branch. This effect is not surprising because the

parasympathetic branch is dominant when animals are asleep, as was the case when the rats were exposed to the noise. The elevations of HR and MAP seen during the daily exposure to white noise are consistent with data obtained by other investigators from rodents exposed to stressful situations, such as handling, restraint, cage-changes and injections (Sales, 1972; Kramer et al., 1993; Kramer et al., 2000; Sharp, Zammit, Azar, & Lawson, 2002; Sharp et al., 2003).

It might be argued that since the cardiovascular effects of noise only resulted in small increases in HR and BP (about 10-15% of initial values) that noise would not be a major confounding factor in rodent experiments. However, the stimuli used in these studies were only delivered once a day, at the same time every day and for short duration, unlike the audible sounds that routinely occur in animal facilities. As reported by other authors, noise levels peak many times during the day in an animal facility and contain a wide range of frequencies (Pfaff & Stecker, 1976; Sales et al., 1988; Milligan et al., 1993). Because noise levels in animal facilities tend to be poorly controlled, the cardiovascular state of the animals may also be poorly controlled and unpredictable. Although stress does not always compromise health and welfare, and in fact the stress response is necessary for survival in the wild, stress always disturbs the body's homeostasis and imposes a cost to the body, particularly when it is elicited repeatedly. This cost arises if stress-induced mediators, such as adrenal hormones, neurotransmitters, cytokines etc., are released too often.

Not only does exposure to 90 dB white noise alter cardiovascular parameters in rats; the small intestine and mesenteric microvessels become inflamed. It is not clear whether this response is mediated via the hypothalamic-pituitary-adrenal axis because accurate measures of plasma corticosterone concentrations before and during the noise could not be obtained without causing further stress to the animals. Windle et al. (1998) found that plasma corticosterone concentrations in rats varied periodically throughout the day but increased significantly in response to 114 dB noise for 10 min., if the onset of the noise coincided with the rising phase of a basal corticosterone pulse. This result suggests that the intestinal responses observed in the present study in response to noise may have been a stress response that was mediated via the hypothalamic-pituitary-adrenal axis.

The intestinal damage appeared to be oxidative in nature. Activated phagocytes, such as neutrophils, eosinophils and macrophages, are the best-recognized sources of free radicals and the intestinal mucosa of rats exposed to noise showed significantly larger numbers of eosinophils in the villi lamina propria compared to 'quiet' rats. These eosinophils were probably recruited by the presence of degranulated mast cells. Activated mast cells can release interleukin-5 (IL-5) that attracts eosinophils (28). In fact our electron micrographs often demonstrated eosinophils and degranulated mast cells in close juxtaposition (Figure 2b). The ROS and other products released by eosinophils may be partly responsible for the epithelial disruption observed near the Peyers' patches of 'noise' rats.

In summary, exposure of rodents to chronic noise appears to induce a

stress response, as demonstrated by behavioral changes and increases in HR and MAP, that is accompanied by intestinal and microvascular inflammation, possibly triggered by increased activation of the immune system.

References

Baldwin, A.L., Primeau, R., & Johnson, W. (2006). Effect of noise on the morphology of the intestinal mucosa in laboratory rats. *Contemporary Topics of Laboratory Animal Science*, **45** (1), 74-82.

Baldwin, A.L., & Bell, I.R. (2007). Effect of noise on microvascular integrity in laboratory rats. *Journal of American Assoc. for Laboratory Animal Science*, **46** (1), 58-65.

Burwell, A.K., & Baldwin, A.L. (2006). Do audible and ultrasonic sounds of intensities common in animal facilities affect the autonomic nervous system of rodents? *Journal of Applied Animal Welfare Science*, **9** (3), 179-199.

Clough, G. (1982). Environmental effects of animals used in biomedical research. *Biological Reviews of the Cambridge Philosophical Society*, **57**, 487-523.

Kramer, K., van Acker, S.A.B.E., Voss, H.P., Grimbergen, J.A., van der Vijgh, W.J.F., & Bast, A. (1993). Use of telemetry to record electrocardiogram and heart rate in freely moving mice. *Journal of Pharmacological Toxicological Methods*, **30**, 209-215.

Kramer, K., Voss, H.-P., Grimbergen, J.A., Mills, P.A., Huetteman, D., Zwiers, L., & Brockway, B. (2000). Telemetric monitoring of blood pressure in freely moving mice: A preliminary study. *Laboratory Animals*, **34**, 272-280.

Mayer, E.A., Naliboff, B.D., & Chang, L. (2001). Basic pathophysiologic mechanisms in inflammatory bowel syndrome. *Digestive Diseases*, **19**, 212-218.

Milligan, S.R., Sales, G.D., & Khirnykh, K. (1993). Sound levels in rooms housing laboratory animals: an uncontrolled daily variable. *Physiology and Behavior*, **53**, 1067-1076.

Mishra, A., S.P. Hogan, E.B. Brandt et al.. (2000). Peyer's patch eosinophils: Identification, characterization, and regulation by mucosal allergen exposure, interleukin-5, and eotaxin. *Blood*, **96** (4),1538- 1544.

Niu, X., Ibbotson, G., & Kubes, P. (1996). A balance between nitric oxide and oxidants regulates mast cell dependent neutrophil-endothelial cell interactions. *Circulation Research*, **79**, 922-999.

Pfaff, J., & Stecker, M. (1976). Loudness level and frequency content of noise in the animal house. *Laboratory Animals*, **10**, 111-117.

Poole T. (1997). Happy animals make good science. *Laboratory Animals*, **10**, 111-117.

Sales, G.D. (1972). Ultrasound and aggressive behaviour in rats and other small mammals. *Animal Behavior*, **20**, 88-100.

Sales, G.D., Wilson, K.J., Spencer, K.E.V., & Milligan, S.R. (1988). Environmental ultrasound in laboratories and animal houses: A possible cause for concern in the welfare and use of laboratory animals. *Laboratory Animals*, **22**, 369-375.

Sharp, J.L., Zammit, T.G., Azar, T.A., & Lawson, D.M. (2002). Stress-like responses to common procedures in male rats housed alone or with other rats. *Contemporary Topics of Laboratory Animal Science*, **41**, 8-14.

Sharp, J.L., Azar, T.A., & Lawson, D.M. (2003). Does cage size affect heart rate and blood pressure of male rats at rest or after procedures that induce stress-like responses? *Contemporary Topics of Laboratory Animal Science*, **42**, 8-12.

Windle, R.J., Wood, S.A., Lightman, S.L., & Ingram, C.D. (1998). The pulsatile characteristics of hypothalamo-pituitary-adrenal activity in female Lewis and Fischer 344 rats and its relationship to differential stress responses. *Endocrinology*, **139** (10), 4044-4052.

International Journal of Comparative Psychology, 2007, **20**, 145-158.
Copyright 2007 by the International Society for Comparative Psychology

The Effect of Transportation Noise on Health and Cognitive Development: A Review of Recent Evidence

Charlotte Clark and Stephen A. Stansfeld
Barts & the London School of Medicine
University of London, United Kingdom

Noise from transport is an increasingly prominent feature of the urban environment. Whilst the auditory effects of noise on humans are established, non-auditory effects - the effects of noise exposure on human health, well-being and cognitive development - are less well established. This narrative review evaluates recent studies of aircraft and road traffic noise that have advanced or synthesized knowledge about several aspects of adult and child health and cognition. Studies have demonstrated a moderate effect of transport noise on hypertension, cardiovascular disease and catecholamine secretion: there is also evidence for an effect on psychological symptoms but not for the onset of more serious clinically defined psychiatric disorder. One way noise may affect health is through annoyance: noise causes annoyance responses in both children and adults and annoyance may cause stress-responses and subsequent illness. Another possible mechanism is sleep disturbance: transport noise has been found to disturb sleep in laboratory and field studies, although there is evidence for adaptation to noise exposure. For children effects of aircraft and road traffic noise have been observed for impaired reading comprehension and memory skills: there is equivocal evidence for an association with blood pressure. To date most health effects have been very little researched and studies have yet to examine in detail how noise exposure interacts with other environmental stressors. In conclusion, noise is a main cause of environmental annoyance and it negatively affects the quality of life of a large proportion of the population. In addition, health and cognitive effects, although modest, may be of importance given the number of people increasingly exposed to environmental noise and the chronic nature of exposure.

Exposure to noise in the environment from transport sources is an increasingly prominent feature of the environment. The growing demand for air and road travel means that more people are being exposed to noise, and noise exposure is increasingly being seen as an important environmental public health issue.

The direct effect of sound energy on human hearing is well established and accepted. Exposure to continuous noise of 85-90 dBA (decibels, A-weighted to approximate the typical sensitivity of the human ear) can lead to progressive hearing loss and changes in threshold sensitivities (Kryter, 1985): similar damage can be caused by exposure to a smaller number of noise events, if the sound energy is great (>135 dB Lc_{pk}, Babisch, 2005) (LC_{pk} is a measurement of peak sound pressure level over a specified period). Auditory effects of noise have typically been observed in certain industrial occupations, hence protective legislation requiring hearing protectors to be worn, however, effects are also increasingly being observed due to entertainment noise from amplified music and MP3 players.

In contrast, non-auditory effects of noise on human health are not the direct result of sound energy. Instead, these effects are the result of noise as a general stressor: thus the use of the term noise not sound: noise is unwanted sound. Non-auditory effects of noise include sleep disturbance, mental health, physiological

Correspondence concerning this article should be addressed to Charlotte Clark, Centre for Psychiatry, Barts and the London School of Medicine and Dentistry, University of London, Charterhouse Square, London EC1M 6BQ, U.K. (c.clark@qmul.ac.uk).

function, and annoyance, as well as effects on cognitive outcomes such as speech communication, and cognitive performance (WHO, 2000). These effects of noise are less well established and accepted than auditory effects.

Noise could indirectly result in poor health in several ways. Firstly, acute noise exposure directly causes a number of predictable short-term physiological responses such as increased heart rate, blood pressure, and endocrine outputs. Chronic noise exposure may cause longer-term activation of these responses and subsequent symptoms and illness. Whether acclimation of the physiological response occurs with long-term noise exposure is not certain. Secondly, these physiological responses may be activated by annoyance. Noise causes annoyance, especially if an individual feels their activities are being disturbed or if it causes difficulties with communication. In some individuals, this annoyance may lead to stress responses, and potentially to subsequent symptoms and illness. However, there is little evidence to directly support the annoyance pathway as a mechanism for non-auditory effects. Habituation[1] of behavioral or psychological responses may occur with long-term exposure for certain individuals or for certain types of behavioral responses: however, the reduction of a behavioral or psychological response may not necessarily result in the acclimation of a physiological response.

This narrative review evaluates recent studies of transport noise that have advanced or synthesized the knowledge about several non-auditory effects: namely, hypertension and coronary heart disease, stress hormones, sleep disturbance, mental health, and cognitive development: effects for children and adults are discussed. Recent years have seen several methodological advancements in the field including the use of larger epidemiological community samples; better characterization of noise measurement; and more detailed measures of health. Evidence from longitudinal studies is beginning to emerge and studies have started to examine exposure-effect relationships, to identify thresholds for noise effects on health and cognition which can be used to inform guidelines for noise exposure. There has also been a better assessment of confounding factors: noise exposure and health are often confounded by socioeconomic position, so individuals living in poorer social circumstances are more likely to have poorer health, as well as be exposed to noise. Therefore, measures of socioeconomic position need to be taken into account when examining associations between noise exposure and health. Furthermore, factors that confound physiological health outcomes such as smoking, diet, and activity levels also need to be measured and adjusted for in analyses.

Review of the Evidence

Noise Exposure Assessment

Assessments of noise exposure use established metrics of external noise exposure which indicate the average sound pressure level for a specified period

[1] Habituation is distinguished from acclimation in this paper in the following way. Habituation refers to the lessening of a behavioural or psychological response to noise, with repeated or chronic exposure: e.g. a reduction in sleep disruption or annoyance responses. Acclimation refers to the lessening of a physiological response to noise, with repeated or chronic exposure: e.g. a reduction in cortisol levels.

using dBA as the measurement unit (dBA is the unit of A-weighted sound pressure level where A-weighted means that the sound pressure levels in various frequency bands across the audible range have been weighted in accordance with differences in hearing sensitivity at different frequencies). Metrics typically employed are L_{Aeq16} and L_{day} which indicate average noise exposure (in dBA units) over a 16 hour daytime period usually 7am-11pm; L_{night} which indicates noise exposure at night (11pm-7am); and L_{dn} which combines the day and night measures to indicate average noise exposure over the 24 hour period, with a 10dB penalty added to the night-time noise measure. These metrics are usually modeled using Geographical Information Systems. Some studies measure noise exposure in the community, which is less reliable if measurements cover short time-periods. Studies have also examined exposure to maximum noise levels (e.g. L_{Amax} - maximum sound pressure in dBA units), as in pathophysiological terms it is not clear whether overall 'dose' of noise exposure is important in determining effects on health or whether peak sound pressure of events or the number of noise events might be important.

Whilst people are often exposed to sounds from more than one source, to date, studies have tended to focus upon only one type of noise exposure, such as aircraft or road traffic noise. Studies that have examined ambient noise and, thus, exposure to more than one source (e.g. Lercher, Evans, Meis, & Kofler, 2002) have not been able to attribute health effects to specific noise sources within the environment. Little is known about the effects on health of combined exposure and it is possible that combined exposure has a cumulative impact or it could be synergistic (see Nilsson & Berglund, 2001). Furthermore, noise exposure often co-occurs with air pollution, because of source-specificity, and studies have yet to explore the implications of probable interactions between noise and air pollution for human health.

Annoyance

It is beyond the limits of this paper to include a review of the effect of noise exposure on annoyance responses. Annoyance is a multifaceted psychological concept including both evaluative and behavioral components (Guski, Schuemer, & Felscher-Shur, 1999), used to describe negative reactions to noise. Annoyance is an important health effect of noise (WHO, 2000). Annoyance is the most reported problem caused by transport noise exposure and is often the primary outcome used to evaluate the effect of noise on communities. Acoustic factors such as noise source, exposure level and time of day of exposure only partly determine an individual's annoyance response: many non-acoustical factors such as the extent of interference experienced, ability to cope, expectations, fear associated with the noise source, noise sensitivity, anger, and beliefs about whether noise could be reduced by those responsible influence annoyance responses (WHO, 2000). Studies have derived exposure-effect associations for the effects of different noise sources on annoyance responses (Miedema & Vos, 1998; Miedema & Oudshoorn, 2001), finding that aircraft noise produces greater annoyance responses than road traffic noise at the same level of exposure.

Hypertension & Coronary Heart Disease

Epidemiological evidence for effects of noise on coronary heart disease and coronary risk factors in adults has been mixed. These inconsistencies may be attributable to the use of varying outcome measures, ranging from weaker self-report measures of hypertension and drug use to more objective measures of blood pressure: as well as to whether confounding factors associated with coronary heart disease such as age, gender, smoking, and body mass index have been taken into account.

Evidence for effects of transport noise exposure on hypertension and ischaemic heart disease is strengthening (Babisch, 2006a). The unique multi-centre HYENA study found increased risk of hypertension related to long-term noise exposure, for both night-time aircraft noise and daily average road traffic noise, for individuals who had lived near to one of six major European airports for five years or more (Jarup et al., 2008). The analyses adjusted for important confounders (age, gender, body mass index, alcohol intake, physical activity, education) and had a good measure of hypertension based upon blood pressure measurements, supplemented by self-reports of a diagnosis of hypertension and/or use of anti-hypertensive medication. Another recent study demonstrated an effect of aircraft noise exposure on the use of anti-hypertensive drugs around Cologne-Bonn airport, particularly for those exposed to night noise (Greiser, Greiser, & Janhsen 2007): however, no data about confounding factors was included in the analyses. A study of road traffic noise and medication use which did adjust for confounders found an effect but only for subjects between 45-55 years and for those exposed to >55 dBA L_{den} (de Kluizenaar, Gansevoort, Miedema, & de Jong, 2007). A study of over 28,000 blood pressure records from around Kadena airport in Okinawa, Japan, found a dose-response relationship between aircraft noise exposure and systolic blood pressure (Odds ratio (OR)=1.29 95% Confidence Intervals (CI)=1.13-1.47) after taking age, gender and body mass index into account: however, no effect was found for diastolic blood pressure, although a weaker measure of self-reported hypertension did show an association with noise exposure (Matsui et al., 2001). Similarly, a study around Arlanda airport in Sweden found that self-reported hypertension was more prevalent among people exposed to average aircraft noise levels of at least 55dBA (LA_{eq}) or maximum levels above 72 dBA (L_{Amax}), after taking age, gender, smoking and education into account (Rosenlund, Berglind, Pershagen, Jarup, & Bluhm, 2001). A recent Swedish study found an association between road traffic noise exposure and self-reported hypertension, after taking age, gender, smoking, occupation and house type into account (Bluhm, Berglind, Nordling, & Rosenlund, 2007): (OR=1.38 95%CI 1.06-1.80 per 5dBA increase in noise exposure). Associations were stronger for those who had lived at the address for more than 10 years and for females. However, a German study of incidence of myocardial infarction found an effect of road traffic noise only for males who had lived at their address for at least 10 years (Babisch, Beule, Schust, Kersten, & Ising, 2005). An effect of aircraft noise on incidence of myocardial infarction has also been demonstrated for individuals exposed to >50 $L_{Aeq24\ hours}$, with stronger associations found for older subjects (Eriksson et al., 2007).

Meta-analyses have established that noise has a significant effect on risk for hypertension and coronary heart disease. A meta-analysis found that for aircraft noise a 5 dBA rise in noise was associated with a 25% increase in risk of hypertension compared with those not exposed to noise (van Kempen et al., 2002). Two meta-analyses of the effect of road traffic noise exposure on coronary heart disease, where outcomes ranged from blood pressure and hypertension to ischaemic heart disease and myocardial infarction found that environmental noise above 65-70dBA was associated with a 10 to 50% increase in risk (Babisch, 2000; 2006a). A recent study estimated that 3% of the total cases of myocardial infarction in Germany are attributable to road traffic noise (Babisch, 2006b).

There is some evidence for annoyance as a possible mediating factor between noise and cardiovascular outcomes. A ten year study of nearly 4000 men from Caerphilly in Wales, found that high annoyance at baseline predicted incidence of coronary heart disease many years later but only for men who were free of chronic disease at baseline: for men with chronic disease at baseline, noise exposure but not annoyance was associated with the incident of coronary heart disease (Babisch, Ising, & Gallacher 2003). This suggests that noise annoyance may have a moderating effect on the development of coronary heart disease. A recent study of 3000 residents in a city in Serbia found that men who were extremely annoyed by traffic noise had an increased risk of reporting hypertension and myocardial infarction, compared with those not annoyed; no similar relationship was observed for women (Belojevic & Saric-Tanaskovic, 2002). However, these cross-sectional findings should be treated cautiously, as men with cardiovascular disease may be more likely to develop annoyance in response to noise. Further, longitudinal research on annoyance as a mediating factor is required.

Epidemiological evidence for effects of noise on coronary risk factors in children has been mixed, which may be due to a number of methodological problems including lack of control for confounding factors, such as parental blood pressure, as well as being limited to considering the effect of noise exposure at school (van Kempen et al., 2006). A cross-sectional study around Schiphol (Amsterdam) and Heathrow (London) airports found an effect of aircraft noise at home, as well as night time aircraft noise exposure on systolic and diastolic blood pressure for 9-10 year old children but no effect for aircraft noise at school (van Kempen et al., 2007); these findings suggest that it may specifically be aircraft noise exposure during the evening and night that affects children's blood pressure. For road traffic noise exposure, this study found that exposure at school was associated with decreased systolic and diastolic blood pressure. A study of younger children, aged 3-7 years, found an association between night-time road traffic noise exposure at home and systolic blood pressure, as well as an effect of day-time road traffic noise exposure at kindergarten (Belojevic, Jakovljevic, Stojanov, Paunovic, & Ilic, 2007). Whilst these recent studies are methodologically stronger than previous studies, additional studies focusing on the effect of different noise sources, in different settings are required before further conclusions can be drawn about noise effects on children's blood pressure.

Stress Hormones

Studies of endocrine markers of noise exposure have demonstrated conflicting results. Adrenaline, noradrenaline and cortisol, all of which are released by the adrenal glands in situations of stress, have been examined. One difficulty in studying these hormones is that salivary and urinary measures of these hormones are easily biased by unmeasured factors; studies also often have small sample sizes. Cortisol, in particular, is difficult to examine, as it has diurnal variation and is usually high in the morning and low in the evening making it difficult to measure effectively.

Evidence of effects of road traffic noise exposure on endocrine markers in adults is weak and inconclusive (see Babisch, 2003): one study found an effect of being exposed to levels above 65 dBA for raised cortisol but not adrenaline levels, although this was on a sample of only 28 individuals (Poll, Straetemans, & Nicolson, 2001). A larger study found an effect of road traffic noise on noradrenaline but not adrenaline (Babisch, Froome, Beyer, & Ising, 2001).

The findings of studies of noise effects on endocrine markers in children are similarly mixed, despite larger sample sizes. Two of the largest studies to date, examining children living near Heathrow airport in West London, found no association between aircraft noise exposure above 66 dBA L_{Aeq} and morning salivary cortisol measures (Haines, Stansfeld, Job, Berglund, & Head, 2001a), nor, in a similar study, between aircraft noise exposure above 62 dBA L_{Aeq} and twelve-hour urinary cortisol, adrenaline and noradrenaline measures (Haines et al., 2001b).

Overall, further studies on the effects of noise on endocrine responses are required. Previous studies of adults are hampered by their small sample sizes, which may reflect the unwillingness of individuals to provide biological samples. As well as inconclusive evidence, little is known about whether raised endocrine responses observed in some studies represent normal short-term responses to environmental stress or a longer-term activation of the endocrine system. There is a lack of understanding about how long-term activation of the endocrine system links to health impairment and whether endocrine responses can habituate to noise exposure is not certain.

Sleep Disturbance

Exposure to night-time noise can potentially interfere with the ability to fall asleep, shorten sleep duration, cause awakenings and reduce perceived quality of sleep (Michaud, Fidell, Pearsons, Campbell, & Keith, 2007) and could affect health in two ways. Firstly, by impacting on biological responses, such as increasing heart rate, awakenings and sleep quality, as the individual responds to stimuli in the environment (HCN, 2004). Activation of some biological responses could have long-term effects on health. Secondly, sleep disturbance can impact on well-being, causing annoyance, irritation, low mood, fatigue, and impaired task performance (HCN, 2004). In terms of noise exposure, it has been suggested that continuous noise exposure is more likely to interrupt REM sleep, whilst intermittent

noise is more likely to interfere with slow wave sleep (Passchier-Vermeer, Vos, Steenbekkers, van der Ploeg, & Groothuis-Oudshoorn, 2002).

Research on evidence for an effect of noise exposure on sleep disturbance is generally stronger from laboratory studies than from field studies. However, comparison between the findings of laboratory and field studies can be limited as laboratory studies tend to involve individuals who are not chronically exposed to noise, whereas, individuals who are chronically exposed to noise may exhibit habituation, where sleep disturbance becomes diminished, following a period of chronic noise exposure. A notable recent laboratory study tried to simulate the effect of aircraft noise exposure on sleep for 128 subjects over 13 nights (Basner & Samel, 2005). Prior to the experiment, the subjects spent a noise-free adaptation night in the laboratory, as sleep is initially affected by the laboratory setting. The experiment demonstrated a prominent first night exposure effect of noise on sleep disturbance, which wore off by the second night, which was interpreted as indicating habituation to noise exposure. On the subsequent nights no significant change in sleep structure was observed if the number of noise events and maximum sound pressure level did not exceed 4*80dB, 8*70dB, 16*60dB, 32*55dB, and 64*45dB. However, this study is still limited by having examined short-term exposure to aircraft noise, and conclusions cannot be drawn from these findings about the long-term effects of exposure to aircraft noise on sleep structure (Basner & Samel, 2005).

Overall, community studies of noise exposure, examining individuals in their homes exposed to their usual noise exposures at night, have found evidence for a direct effect of noise on sleep disturbance. However, recent reviews, assessing the strength of the evidence, differ in their conclusions. A recent synthesis of field studies concluded that there was sufficient evidence that night-time noise exposure was causing direct biological responses, at approximately 40dB SEL (Sound Exposure Level), as well as affecting well-being and quality of sleep (HCN, 2004). This report found that evidence was weaker for an effect of night-time noise on social interaction, task performance, on specific disease symptoms or on fatal accidents at work. Similarly, a meta-analysis of 24 field studies, including almost 23,000 individuals exposed to night-time noise levels ranging from 45-65dBA, found that aircraft noise was associated with greater self-reported sleep disturbance than road traffic, and road traffic noise with greater disturbance than railway noise (Miedema & Vos, 2007). This analysis also found an inverted U-shaped association between noise induced sleep disturbance and age, with the greatest disturbance being found for individuals aged 50-56 years. The study concluded that transportation noise was a widespread factor affecting sleep.

In contrast, a recent review focusing solely on aircraft noise exposure concluded that findings about noise-induced sleep disturbance differ considerably (Michaud et al., 2007). The review of five studies found little evidence for an effect of outdoor noise on sleep disturbance, whilst indoor noise was associated more closely with sleep outcomes. However, there was evidence from several studies that a greater number of awakenings occur that are either spontaneous or attributable to other noise in the home, than are attributable to aircraft noise.

The equivocal conclusions of these reviews may be because the studies are comparing studies which examine a range of outcomes ranging from more objective measures of sleep disturbance, such as polysomnography and wrist-actimetry, which measures sleep disturbance based on body movements, to subjective measures, such as self-reported sleep disturbance. The measurement of sleep disturbance is challenging, as no one physical or psychological measure is accurate or reliable. The equivocal conclusions may also reflect different exposure assessments: some studies use external noise exposure, whilst others measure noise exposure in the bedroom (Miedema & Vos, 2007).

Evidence from recent studies where change in night-time noise exposure has occurred also provides some evidence for an association between noise and sleep disturbance. Whilst a Swedish study found that a reduction in road traffic noise exposure caused by a new road tunnel was associated with improvements in sleep quality and alertness, measured by actimetry and subjective reports (Öhrström, 2002), a change in night-time aircraft noise exposure at two airports was not associated with changes in noise induced sleep disturbance (Fidell, Pearsons, Tabachnick, & Howe, 2000). Few studies have included children in studies of sleep disturbance: one study used sleep logs and actigraphy to compare the effect of road traffic noise on child and parent sleep, finding an exposure-effect relationship between road traffic noise exposure and sleep quality and daytime sleepiness for children, and an exposure effect association between road traffic noise and sleep quality, awakenings, and perceived interference from noise for the parents (Öhrström, Hadzibajramovic, Holmes, & Svensson, 2006).

In conclusion, overall, there is sufficient evidence that night-noise can disturb sleep, as well as potentially affect well-being. The field still lacks longitudinal evidence, which would enable the causal association between noise exposure and the long-term health implications of biological responses and impaired well-being, related with night-time noise exposure to be examined.

Psychological Health

Given the effect of chronic noise exposure on annoyance responses, it has been hypothesized that chronic noise exposure could have a serious effect on psychological health, as noise can cause annoyance and prolonged annoyance could lead to poor psychological health (McLean & Tarnopolsky, 1977). The effect of noise on psychological health is complicated as studies have found that poorer psychological health is also associated with greater annoyance responses (Tarnopolsky, Barker, Wiggins, & McLean 1978; van Kamp, Houthuijs, van Wiechen, & Breugelmans, 2007) and greater noise sensitivity (Stansfeld, Clark, Jenkins, & Tarnopolsky, 1985; Miyakawa, Matsui, & Hiramatsu, 2007).

Studies of adults have found that noise exposure relates to an increase in the number of psychological symptoms reported, such as symptoms of anxiety and depression, rather than to clinically diagnosable psychiatric disorders (Tarnpolsky et al., 1978; Stansfeld, Sharp, Gallacher, & Babisch, 1993). A later study examined nearly 6000 inhabitants around two military airbases in Japan, and found that those exposed to noise levels of 70 L_{dn} or above had higher rates of mental instability

and depressiveness (Hiramatsu, Yamamoto, Taira, Ito, & Nakasone, 1997). Additionally, those who were more annoyed showed higher risk of mental and somatic symptoms. Unfortunately, this study did not assess psychiatric diagnoses, but a recent study has found associations between noise exposure and psychiatric diagnoses as measured by the Composite International Diagnostic Interview (Hardoy et al., 2005), with individuals living close to an airport showing higher frequency of 'generalized anxiety disorder' and 'anxiety disorder not otherwise specified', compared with matched controls from another area. These findings need replication and unfortunately, it is not possible to distinguish cause from effect in these studies, which are all cross-sectional, measuring noise and psychological health concurrently. A longitudinal study around Schiphol airport in Amsterdam found no association between noise exposure levels and mental health either at baseline, or after the opening of a fifth runway (van Kamp et al., 2007).

Several recent studies have examined associations between noise exposure and children's psychological health. The Tyrol Mountain Study compared child and teacher ratings of psychological health for children exposed either to <50 or > 60 dBA L_{dn} (Lercher et al., 2002). Ambient noise (road and rail) exposure was associated with teacher ratings of psychological health but was only associated with child rated psychological health for children with early biological risk (low birth weight or premature birth). A study of children attending school near Heathrow airport in London also found that noise exposed children had higher levels of psychological distress (Haines et al., 2001b), as well as a higher prevalence of hyperactivity. The RANCH study, the largest study of road traffic and aircraft noise exposure on children's psychological health to date, failed to replicate an effect of either aircraft or road traffic noise on psychological distress in samples from the Netherlands, Spain or the UK (Stansfeld et al., 2005): however, the effect of aircraft noise on hyperactivity was replicated.

Overall, studies suggest that for both adults and children noise exposure is probably not associated with serious psychological illness but there may be effects on well-being and quality of life: this conclusion is limited by the lack of longitudinal research in this field. There is a need for further research, especially to establish if hyperactive children are more susceptible to stimulating environmental stressors such as noise.

Cognitive Development

It has been suggested that children may be especially vulnerable to effects of environmental noise as they may have less cognitive capacity to understand and anticipate environmental stressors, as well as a lack of developed coping repertoires (see Stansfeld, Haines, & Brown, 2000). Exposure during critical periods of learning at school could potentially impair development and have a lifelong effect on educational attainment. Whilst a recent study suggests that children may not be more susceptible to environmental noise effects on cognitive performance than adults (Boman, Enmarker, & Hygge, 2005), studies have established that children exposed to noise at school experience some cognitive impairments, compared with children not exposed to noise: tasks affected are those involving central processing

and language such as reading comprehension, memory and attention (Haines et al. 2001a; 2001b; Evans & Maxwell, 1997; Cohen, Glass, & Singer, 1973).

One of the most interesting and compelling studies in this field is the naturally occurring longitudinal quasi-experiment reported by Evans and colleagues, examining the effect of the relocation of Munich airport on children's health and cognition (Evans, Hygge, & Bullinger, 1995; Evans, Bullinger & Hygge, 1998; Hygge, Evans, & Bullinger, 2002). In 1992 the old Munich airport closed and was relocated. Prior to relocation, high noise exposure was associated with deficits in long term memory and reading comprehension. Two years after the closure of the airport, these deficits disappeared, indicating that noise effects on cognition may be reversible if exposure to the noise ceases. Most convincing was the finding that deficits in memory and reading comprehension developed over the two year follow-up for children who became newly noise exposed near the new airport.

The recent large scale RANCH study, which compared the effect of road traffic and aircraft noise on children's cognitive performance in the Netherlands, Spain and the UK, found a linear exposure-effect relationship between chronic aircraft noise exposure and impaired reading comprehension and recognition memory, after taking a range of socioeconomic and confounding factors into account (Stansfeld et al., 2005). No associations were observed between chronic road traffic noise exposure and cognition, with the exception of episodic memory, which surprisingly showed better performance in high road traffic noise areas. Neither aircraft noise nor road traffic noise affected attention or working memory. In terms of the magnitude of the effect of aircraft noise on reading comprehension, a 5dBA L_{eq16} increase in aircraft noise exposure was associated with a 2 month delay in reading age in the UK and a 1 month delay in the Netherlands (Clark et al., 2006): this association remained after adjustment for aircraft noise annoyance and cognitive abilities including episodic memory, working memory and attention. Thus, whilst aircraft noise has only a small effect on reading comprehension, it is possible that children may be exposed to aircraft noise for many of their childhood years and the consequences of long-term noise exposure on reading comprehension and further cognitive development remain unknown.

The findings of the RANCH study, along with previous findings (Haines et al., 2001b; Hygge et al., 2002) suggest that noise may directly affect reading comprehension or could be accounted for by other mechanisms including teacher and pupil frustration (Evans & Lepore, 1993), learned helplessness (Evans & Stecker, 2004) and impaired attention (Cohen et al., 1973; Evans & Lepore, 1993). It has been suggested that children may adapt to chronic noise exposure by filtering or tuning out the unwanted noise stimuli: this filter may then be applied indiscriminately to situations where noise is not present, leading to learning deficits through lack of attention.

Discussion

In summary, there is convincing evidence for non-auditory effects of noise on health and cognition for some outcomes. Evidence for the effect of aircraft noise on children's cognitive performance is strong. Evidence for health outcomes

is increasing and there is consistent evidence for a small but significant effect of transport noise on hypertension and coronary heart disease. Furthermore, there is sufficient evidence for an effect of noise on sleep disturbance. Evidence for an effect of noise on endocrine markers is weak and inconclusive, especially for adults. Health effects of noise on the endocrine system cannot yet be ruled out and further, large scale studies are required focusing on adults.

Evidence for an effect of noise on psychological health suggests that for both adults and children noise is probably not associated with serious psychological ill-health but may affect quality of life and well-being. As yet, there are no prospective studies published on the effects of noise exposure on psychological health and few studies examine psychiatric diagnoses. The conclusions from cross-sectional evidence should be treated cautiously, as individuals who are experiencing poor mental health are more likely to also evaluate the environment negatively, bringing into question the direction of causality between noise exposure and mental health.

In conclusion, noise is a main cause of environmental annoyance and it negatively affects the quality of life of a large proportion of the population. In addition, health and cognitive effects, although modest, may be of importance given the number of people increasingly exposed to environmental noise and the chronic nature of exposure. Future research needs to further develop understanding not only of the magnitude of effects and exposure-effect relationships, which can inform interventions and policy, but also needs to further consider mechanisms for the effects such as the role of annoyance, adaptation, habituation, acclimation, and coping strategies and the role these may play in non-auditory effects of noise.

References

Babisch, W. (2006a). Transportation noise and cardiovascular risk: Updated review and synthesis of epidemiological studies indicate that the evidence has increased. *Noise & Health*, **8**(30), 1-29.

Babisch, W. (2006b). *Transportation noise and cardiovascular risk: Review and synthesis of epidemiological studies, dose-effect curve and risk estimation*. Dessau, Germany:Umweltbundesamt/Federal Environmental Agency.

Babisch, W. (2005). Noise and health. *Environmental Health Perspectives,* **113**(1), A14-A15.

Babisch, W. (2003). Stress hormones in the research on cardiovascular effects of noise. *Noise & Health,* **5**(18), 1-11.

Babisch, W. (2000). Traffic noise and cardiovascular disease: Epidemiological review and synthesis. *Noise and Health,* **8**, 9-32.

Babisch, W., Beule, B., Schust, M., Kersten, N., & Ising, H. (2005). Traffic noise and risk of myocardial infarction. *Epidemiology*, **16**, 33-40.

Babisch, W., Ising, H., & Gallacher J.E. (2003). Health status as a potential effect modifier of the relation between noise annoyance and incidence of ischaemic heart disease. *Occupational & Environmental Medicine,* **60**(10), 739-745.

Babisch, W., Froome, H., Beyer, A., & Isling, H. (2001). Increased catecholine levels in urine subjects exposed to road traffic noise: The role of stress hormones in noise research. *Environment International,* **126**(7-8), 475-481.

Basner, M., & Samuel, A. (2005). Effects of nocturnal aircraft noise on sleep structure. *Somnologie*, **9**(2), 84-95.

Belojevic, G. Jakovljevic, B., Stojanov, V., Paunovic, K., & Ilic, J. (2007). Urban road-traffic noise and blood pressure and heart rate in preschool children. *Environment International* E-pub September 2007.

Belojevic, G., & Saric-Tanaskovic, M. (2002). Prevalence of arterial hypertension and myocardial infarction in relation to subjective ratings of traffic noise exposure. *Noise and Health*, **4**(16), 33-37.

Bluhm, G., Berglind, N., Nordling, E., & Rosenlund. M. (2007). Road traffic noise and hypertension. *Occupational & Environmental Medicine*, **64**, 122-126.

Boman, E., Enmarker, I., & Hygge. S. (2005). Strength of noise effects on memory as a function of noise source and age. *Noise & Health*, **7**(27), 11-26.

Clark, C., Martin, R., van Kempen, E., Alfred, T., Head, J., Davies, H.W., Haines, M.M., Lopez Barrio, I., Matheson, M., & Stansfeld, S.A. (2006). Exposure-effect relations between aircraft and road traffic noise exposure at school and reading comprehension: The RANCH project. *American Journal of Epidemiology*, **163**, 27-37.

Cohen, S., Glass, D.C., & Singer, J.E. (1973). Apartment noise, auditory discrimination, and reading ability in children. *Journal of Experimental Social Psychology*, **9**, 407-422.

Eriksson, C., Rosenlund, M., Pershagen, G., Hilding, A., Östenson, C., & Bluhm, G. (2007). Aircraft noise and incidence of hypertension. *Epidemiology*, **18**, 716-721.

Evans, G.W., & Stecker, R. (2004). Motivational consequences of environmental stress. *Journal of Environmental Psychology*, **24**, 143-165.

Evans, G.W., Bullinger, M., & Hygge, S. (1998). Chronic noise exposure and physiological response: A prospective study of children living under environmental stress. *Psychological Science*, **9** (1), 75-77.

Evans, G.W., & Maxwell, L. (1997). Chronic noise exposure and reading deficits: The mediating effects of language acquisition. *Environment and Behavior*, **29** (5), 638-656.

Evans, G.W., Hygge, S., & Bullinger, M. (1995). Chronic noise and psychological stress. *Psychological Science*, **6**(6), 333-338.

Evans, G.W., & Lepore, S.J. (1993). Non-auditory effects of noise on children. *Children's Environments*, **10**, 31-51.

Fidell, S., Pearsons, K., Tabachnick, B.G., & Howe, R. (2000). Effects of sleep disturbance of changes in aircraft noise near three airports. *Journal of the Acoustic Society of America*, **107**(5), 2535-2547.

Greiser, E., Greiser, C., & Janhsen, K. (2007). Night-time aircraft noise increases prevalence of prescriptions of antihypertensive and cardiovascular drugs irrespective of social class – the Cologne-Bonn airport study. *Journal of Public Health*, **15**(5), 327-337.

Guski, R., Schuemer, R., & Felscher-Shur, U. (1999). The concept of noise annoyance: How international experts see it. *Journal of Sound and Vibration*, **223**, 513-527.

Haines, M.M., Stansfeld, S.A., Job, R.F.S., Berglund, B., & Head, J. (2001a). Chronic aircraft noise exposure, stress responses, mental health and cognitive performance in school children. *Psychological Medicine*, **31**, 265-277.

Haines, M.M., Stansfeld, S.A., Brentnall, S., Head, J., Berry, B., Jiggins, M., & Hygge, S. (2001b). The West London Study: The effects of chronic aircraft noise exposure on child health. *Psychological Medicine*, **31**, 1385-1396.

Hardoy, M.C., Carta, M.G., Marci, A.R., Carbone, F., Cadeddu, M., Kovess, V., Dell-Osso, L., & Carpiniello. B. (2005). Exposure to aircraft noise and risk of psychiatric disorders. *Social Psychiatry and Psychiatric Epidemiology*, **40**, 24-26.

HCN (the Health Council of the Netherlands). (2004). The influence of night-time noise on sleep and health. The Hague:Health Council of the Netherlands. Publication No. 2004/14E.

Hiramatsu, K., Yamamoto, T., Taira, K., Ito, A., & Nakasone, T. (1997). A survey on health effects due to aircraft noise on residents living around Kadena airport in the Ryukyus', *Journal of Sound and Vibration*, **205**, 451-460.

Hygge, S., Evans, G.W., & Bullinger, M. (2002). A prospective study of some effects of aircraft noise on cognitive performance in school children. *Psychological Science*, **13**(5), 469-474.

Ising, H., & Braun, C. (2000). Acute and chronic endocrine effects of noise: Review of the research conducted at the institute of water, soil and air hygiene. *Noise and Health*, **2**(7), 7-24.

Jarup, L., Babisch, W., Houthuijs, D., Pershagen, G., Katsouyanni, K., Cadum, E., Dudley, M., Savigny, P., Seiffert, I., Swart, W., Breugelmans, O., Bluhm, G., Selander, J., Haralabidis, A., Dimakopoulou, K., Sourtzi, P., Velonakis, M., & Vigna-Taglianti, V. (2008). Hypertension and exposure to noise near airports: The HYENA study. *Environmental Health Perspectives*, **116**(3), 329-333.

de Kluizenaar, Y., Gansevoort, R.T., Miedema, H.M.E., & de Jong, P.E. (2007). Hypertension and road traffic noise exposure. *Journal of Occupational and Environmental Medicine*, **49**(5), 484-492.

Kryter, K.D. (1985). *The Effects of Noise on Man*. 2nd Edition. Orlando, FL:Academic Press.

Lercher, P., Evans, G.W., Meis, M., & Kofler, W.W. (2002). Ambient neighbourhood noise and children's mental health. Occupational and Environmental Medicine, **59**, 380-386.

Matsui, T., Uehara, T., Miyakita, T., Hiramatsu, K., Osada, Y., & Yamamoto, T. (2001) Association between blood pressure and aircraft noise exposure around Kadena airfield in Okinawa, In Internoise 2001. *Proceedings of the 2001 International Congress and Exhibition on Noise Control Engineering*, The Hague. Vol. 4. Boone R. (ed) Maastricht, Nederlands:Akoestisch Genootschap.

McLean, E.K., & Tarnopolsky, A. (1977). Noise, discomfort and mental health. A review of the socio-medical implications of disturbance by noise. *Psychological Medicine*, **7**(1), 19-62.

Michaud, D.S., Fidell, S., Pearsons, K., Campbell, K.C., & Keith, S.E. (2007). Review of field studies of aircraft noise-induced sleep disturbance. *Journal of the Acoustic Society of America*, **121**(1), 32-41.

Midema, H.M.E., & Vos, H. (2007). Associations between self-reported sleep disturbance and environmental noise based on reanalyses of pooled data from 24 studies. *Behavioral Sleep Medicine*, **5**(1), 1-20.

Midema, H.M.E., & Oudshoorn, C.G. (2001). Annoyance from transportation noise: Relationships with exposure metrics DNL and DENL and their confidence intervals. *Environmental Health Perspectives*, **109**(4), 409-416.

Miyakawa, M., Matsui, T., & Hiramatsu, K. (2007). Relationship between psychiatric disorder and disturbances of daily life due to aircraft noise exposure – epidemiological study around Narita International Airport. Internoise 2007. *Proceedings of the 2007 International Congress and Exhibition on Noise Control Engineering*, Istanbul, Turkey: Turkish Acoustical Society.

Nilsson, M.E. & Berglund, B. (2001). Effects of noise from combinations of traffic sources. *Archives of the Centre for Sensory Research*, **6**, 1-59.

Öhrström, E. (2002). Sleep studies before and after – results and comparison of different methods. *Noise & Health*, **4**(15), 65-67.

Öhrström, E., Hadzibajramovic, E., Holmes, M., & Svensson, H. (2006). Effects of road traffic noise on sleep: Studies on children and adults. *Journal of Environmental Psychology*, **26**(2), 116-126.

Passchier-Vermeer, W., Vos, H., Steenbekkers, J., van der Ploeg, F., & groothuis-Oudshoorn, K. (2002). *Sleep disturbance and aircraft noise exposure: Exposure-effect relationships.* TNO Report No. 2002.027. Den Haag:the Netherlands

Poll, R.V., Straetemans, M., & Nicolson, N.A. (2001). Ambient noise in daily life: A pilot study. In Internoise 2001. *Proceedings of the 2001 International Congress and Exhibition on Noise Control Engineering*, The Hague. Vol. 4. Boone R., ed. Nederlands Akoestisch Genootschap, Maastricht, pp1807-1810.

Rosenlund, M., Berglind, N., Pershagen, G., Jarup, L., & Bluhm, G. (2001). Increased prevalence of hypertension in a population exposed to aircraft noise. *Occupational & Environmental Medicine*, **58**(12), 769-773.

Stansfeld, S.A., Berglund, B., Clark, C., Lopez Barrio, I., Fischer, P., Öhrström E., Haines, M.M., Head, J., Hygge, S., van Kamp, I., & Berry, B.F. (2005). Aircraft and road traffic noise and children's cognition and health: A cross-national study. *The Lancet*, 365, 1942-1949.

Stansfeld, S.A., Haines, M.M., & Brown, B. (2000). Noise and health in the urban environment. *Reviews on Environmental Health*, **15**(1-2), 43-82.

Stansfeld, S.A., Sharp, D.S., Gallacher, J., & Babisch, W. (1993). Road traffic noise, noise sensitivity and psychological disorder. *Psychological Medicine*, **23**(4), 977-985.

Stansfeld, S.A., Clark, C.R., Jenkins, L.M., & Tarnopolsky. A. (1985). Sensitivity to noise in a community sample: II measurement of psychophysiological indices. *Psychological Medicine*, **15**(2), 255-263.

Tarnpolsky, A., Barker, S.M, Wiggins, R.D., & McLean, E.K. (1978). The effect of aircraft noise on the mental health of a community sample: A pilot study. *Psychological Medicine*, **8**, 219-233.

van Kamp, I., Houthuijs, D., van Wiechen, C., & Breugelmans. O. (2007). Environmental noise and mental health: Evidence from the Schiphol monitoring program. In Internoise 2007. *Proceedings of the 2007 International Congress and Exhibition on Noise Control Engineering*, Istanbul, Turkey: Turkish Acoustical Society.

van Kempen, E., van Kamp, I., Fischer, P., Davies, H., Houthuijs, D., Stellato, R., Clark, C., & Stansfeld, S. (2006). Noise exposure and children's blood pressure and heart rate: The RANCH project. *Occupational & Environmental Medicine*, **63**(9), 632-639.

van Kempen, E.E.M.M., Kruize, H., Boshuizen, H.C., Ameling, C.B., Staatsen, B.A.M., & de Hollander, A.E.M. (2002). The association between noise exposure and blood pressure and ischemic heart disease: A Meta-analysis. *Environmental Health Perspectives*, **110**(3), 307-317.

WHO. (2000). *Guidelines for Community Noise*. Geneva:World Health Organisation.

International Journal of Comparative Psychology, 2007, **20**, 159-168.
Copyright 2007 by the International Society for Comparative Psychology

A Brief Review of Known Effects of Noise on Marine Mammals

Linda S. Weilgart
Dalhousie University, Canada

Marine mammals, especially cetaceans, are highly vocal and dependent on sound for almost all aspects of their lives, e.g. food-finding, reproduction, communication, detection of predators/hazards, and navigation. They are thus likely sensitive to anthropogenic noise. Sound has a large potential area of impact, sometimes covering millions of square kilometers of ocean with levels high enough to cause possible disturbance in marine mammals. There can be great variation in the reaction of marine mammals to noise, depending on such factors as species, individual, age, sex, prior experience with noise, and behavioral state. Species with similar hearing capabilities can respond differently to the same noise. Observed effects of noise on marine mammals include: changes in vocalizations, respiration, swim speed, diving, and foraging behavior; displacement, avoidance, shifts in migration path, stress, hearing damage, and strandings. Responses of marine mammals to noise can often be subtle and barely detectable, and there are many documented cases of apparent tolerance of noise. However, marine mammals showing no obvious avoidance or changes in activities may still suffer important, even lethal, consequences. Acoustically-induced strandings may displace a local beaked whale (*Ziphiidae*) population (for an extended period if not permanently) or even possibly eliminate most of its members. As beaked whales seem to be found in small, possibly genetically isolated, resident populations, even a transient and localized acoustic impact could have prolonged population consequences. Observed reactions to noise in marine mammals could theoretically result in impacts such as decreased foraging efficiency, higher energetic demands, less group cohesion, higher predation, decreased reproduction, and thus seriously impact the population. Alternatively, they may be harmless. However, noise is thought to contribute to at least some species' declines or lack of recovery (Southern resident killer whales (*Orcinus orca*), western gray whales (*Eschrichtius robustus*) off Sakhalin).

As sound travels much better than light in the oceans, many marine animals, including marine mammals, use hearing as their primary sense. Cetaceans, in particular, are heavily dependent on sound for food-finding, communication, reproduction, detection of predators, and navigation. They are therefore likely sensitive to the introduction of anthropogenic noise into their environment. Unfortunately, because sound travels further than light in water, sounds have a large potential area of impact. Low frequency sounds, such as naval Low Frequency Active (LFA) sonar and distant shipping, travel especially well and may sometimes be heard over millions of square kilometers of ocean with levels high enough to cause possible disturbance in marine mammals. Seismic surveys can raise the background noise levels by 20 dB over 300,000 sq. km. continuously for days (IWC, 2005). Human use of the sea is growing and thus increasing the amount of noise that we introduce into the oceans (see Hatch & Wright, this issue).

Several reviews have examined the various known effects of noise on marine mammals (e.g., Richardson, Greene, Malme, & Thomson, 1995; Hildebrand, 2005; Nowacek, Thorne, Johnston, & Tyack, 2007; MMC, 2007). Such efforts will not be repeated here. Instead, the intent is to provide an overview

Correspondence concerning this article should be addressed to Linda Weilgart, Department of Biology, Dalhousie University, Halifax, Nova Scotia, Canada B3H 4J1. (lweilgar@dal.ca).

of the various effects that noise is known to have on marine mammals for those new to the subject. Consequently, this is not an exhaustive review. However, the examples do represent a variety of impacts including: changes in vocalizations, respiration, swim speed, diving, and foraging behavior; displacement, avoidance, shifts in migration path, stress, hearing damage, and strandings.

Especially in species as difficult to observe as cetaceans, we are limited in our ability to detect impacts. Thus, failure to find a response to noise may be more due to measuring the wrong variables or an inability to measure the right ones, rather than a true lack of response. Populations may be threatened by noise through, for instance, increased stress levels or masking, yet these effects would be difficult to detect in cetaceans, since only a handful of the ca. 84 species have population estimates that are more precise than ± 40% (Whitehead, Reeves, & Tyack, 2000). The vast majority (72-90%) of serious population declines in cetaceans would not be detected under the current population monitoring effort (Taylor, Martinez, Gerrodette, Barlow, & Hrovat, 2007). Even when responses to noise are found, the biological significance to cetacean populations is hard to discern. Usually, only short-term responses to noise are studied, for practical reasons. However, short-term effects are hard to interpret. They may be an indication of serious population consequences or they may be insignificant. Conversely, long-term population impacts may occur without dramatic or even observable short-term reactions, as has been demonstrated in bottlenose dolphins, *Tursiops* spp. (Bejder, 2005) and caribou, *Rangifer tarandus* (Harrington & Veitch, 1992). Thus, long-term studies are more useful in relating disturbance reactions to population impacts (Bejder, 2005).

Changes in Vocalizations

Increases in vocalizations may represent an attempt by the animal to overcome 'masking,' when a sound is obscured or interfered with, by background noise. Masking can both reduce the range over which signals can be heard and reduce the signal's quality of information. The following observations may or may not be attempts to compensate for masking. Beluga whales (*Delphinapterus leucas*) used specific calls more often and shifted frequencies upward when boats were near (Lesage, Barrette, Kingsley, & Sjare, 1999). St. Lawrence River belugas were also shown to increase the level of their vocalizations as a response to increases in the levels of shipping noise, an indication of a Lombard vocal response (Scheifele et al., 2005). In response to high levels of boat traffic, killer whales increased the durations of their calls (Foote, Osborne, & Hoelzel, 2004). Humpback whales (*Megaptera novaeangliae*) lengthened their mating songs during exposure to LFA sonar (Miller et al., 2000). Pilot whales (*Globicephala melas*) produced more whistles in response to military mid-frequency sonar (Rendell & Gordon, 1999), as did bottlenose dolphins (*Tursiops truncatus*) in response to boat approaches (Buckstaff, 2004).

Marine mammals have also been observed to decrease their vocalizations in response to noise, sometimes ceasing to call entirely for periods of weeks or months. This can have implications for breeding, feeding, or social cohesion,

depending on the calls affected. Decreases in "creaks," thought to be prey capture attempts, have been observed in a Cuvier's beaked whale (*Ziphius cavirostris*) in response to ship noise (Soto et al., 2006), and in sperm whales (*Physeter macrocephalus*) in response to seismic surveys (IWC, 2007). Sperm whales have also been observed falling silent when exposed to pingers (Watkins & Schevill 1975), mid-frequency military sonar signals (Watkins, Moore, & Tyack, 1985), seismic surveys, and low frequency ATOC-like[1] sounds (Bowles, Smultea, Würsig, DeMaster, & Palka, 1994). The ATOC-like sounds and perhaps seismic surveys had similar effects on pilot whales (Bowles et al., 1994), though the power to detect effects in this study was low.

Fin whales (*Balaenoptera physalus*) reduced their calling rates in response to boat noise (Watkins, 1986). About 250 male fin whales stopped singing for weeks-months over 10-20,000 sq. nm. in the presence of a seismic survey, resuming singing within hours-days after the survey ended (IWC, 2007). It is likely that there were breeding consequences of this behavior, as these fin whale calls are thought to function in mating (Croll et al., 2002).

Changes in Diving and Foraging Behavior

Marine mammals have been observed to change their surface behavior (e.g. swim speed, respiration rate, etc.) in the presence of seismic noise, with largely unknown consequences. However, if foraging dives are affected by noise, it is quite likely that there will be associated reductions in foraging efficiency. In addition to other responses, sperm whales undertook no foraging dives when approached closely by a seismic survey vessel emitting airgun noise, and reduced the number of fluke strokes and effort at more distant exposures (IWC, 2007). Similarly, in response to the nearby passage of a noisy ship, a Cuvier's beaked whale was seen to dive for shorter periods, with less time spent echolocating, in addition to a lower production of creaks as was mentioned above (Soto et al., 2006). It was suggested that the combined effects resulted in a 50% reduction in foraging efficiency (Soto et al., 2006).

Northern elephant seals (*Mirounga angustirostris*) increased descent rates and decreased ascent rates similar to an escape response, when exposed to the low-frequency noise of ATOC (Costa et al., 2003). Western gray whales reacted to seismic surveys by swimming faster and straighter over a larger area with faster respiration rates (IWC, 2007). In addition to a tendency for avoidance and less feeding across all cetaceans during seismic surveys, mysticetes generally spent more time at the surface while smaller odontocetes tended to swim faster (Stone & Tasker, 2006). More subtle responses to seismic surveys were also seen at quite large distances. For example, one study found that bowheads (*Balaena mysticetus*) displayed no avoidance or a change in calling or general activities, but were

[1] Acoustic Thermometry of Ocean Climate was an oceanographic project which broadcasted loud sounds across whole ocean basins. It continues to operate under the name NPAL, or North Pacific Acoustic Laborartory.

undertaking shorter dives with a slower respiration rate at distances up to 50-70 km away (Richardson, Würsig, & Greene, 1986; Richardson et al., 1995).

Avoidance and Displacement

Displacement from critical feeding and breeding grounds has been documented in a number of marine mammal species exposed to noise. Possibly the most striking example is the displacement of gray whales from breeding lagoons in response to industrial noise (for over 5 years: Jones, Swartz, & Dahlheim, 1994) or dredging and shipping (displaced for 10 years: Bryant, Lafferty, & Lafferty, 1984). The critically endangered population of western gray whales off Sakhalin Island was also displaced from one of their primary feeding areas by seismic survey activity (IWC, 2005; 2007).

Beluga whales appeared to actively avoid icebreakers at distances of 35-50 km, remaining away for 1-2 days (Finley, Miller, Davis, & Greene, 1990; Cosens & Dueck, 1993). Killer whales were displaced from an area for 6 years by acoustic harassment devices, or AHDs (Morton & Symonds, 2002). Humpback whales avoided seismic surveys, with resting females staying 7-12 km away, although males were occasionally attracted to the sounds (McCauley et al., 2000). In addition, sighting rates of many cetaceans in UK and adjacent waters were significantly lower, and their distance to the seismic noise source (large volume airgun array) significantly higher, during periods when the source was on in comparison to those when it was not (Stone & Tasker, 2006).

Slight, but obvious, shifts in migration paths have also been noted in several species when a noise source was placed in their migration route. For example gray whales adjusted their migration path to avoid an LFA sonar source placed inshore, but not offshore (Tyack & Clark, 1988). In addition, both gray and bowhead whales have been observed detouring around continuous industrial noise (Malme, Miles, Clark, Tyack, & Bird, 1983, 1984; Richardson et al., 1985, Richardson, Würsig, & Greene, 1990).

Strandings and Fatalities

Much attention has been focused recently on acoustically-induced strandings, primarily with respect to beaked whales and military mid-frequency sonar (e.g., Fernandez et al., 2005, Cox et al., 2006). The Bahamas March 2000 mass stranding was one of the best studied of such strandings, and occurred together with naval exercises involving mid-frequency sonar. Several species of whale were found dead with injuries to their acoustic organs. The government acknowledged the fact that "...tactical mid-range frequency sonars aboard U.S. Navy ships…were the most plausible source of this acoustic or impulse trauma." (NOAA & U.S. Navy, 2001). This stranding was the only stranding for which baseline beaked whale survey data were available. Thus, it could be determined that there were no sightings of Cuvier's beaked whales for a 20 month period (May 2000 - February 2002) following the stranding, despite increased field effort in 2000 and 2001 (Claridge, 2006). Sighting rates since February 2002 appeared to be

back to those found from 1997-1999 (Claridge, 2006). The at least temporary and possibly permanent disappearance of pre-stranding known individuals seems to indicate that the affected local population of Cuvier's beaked whales was isolated from a larger population, implying that a population-level effect may have resulted from the brief transit of five naval vessels using sonar (Balcomb & Claridge, 2001; IWC, 2005). It is unknown how many whales from the local population of the species were killed during the naval exercise, but at minimum they were displaced from their former habitat. Beaked whales appear to be found in small, possibly genetically isolated, local populations that are resident year-round (Wimmer & Whitehead, 2004; Balcomb & Claridge, 2001). Such population characteristics make beaked whales particularly vulnerable to disturbance and population impacts.

Other cetacean species may also be involved in acoustically-induced strandings (see ICES, 2005), and the possibility that noise can lead to strandings and/or death in marine mammals exists beyond naval sonar. For instance, seismic noise has been implicated in a stranding of beaked whales (Hildebrand, 2005).

Hearing Damage

Noise has the potential to induce temporary hearing loss (either across the frequencies or more specific to a smaller frequency band), also known as temporary threshold shift (TTS), if it is loud or long enough in duration. In general, the higher the sound level and/or longer the duration, the more likely TTS is to occur. If exposure is prolonged or repeated or even as a result of one very loud noise event, the hearing damage can become permanent, also known as a permanent threshold shift (PTS). Experiments with captive bottlenose and beluga have, however, shown that both tonal (e.g., Schlundt, Finneran, Carder, & Ridgway, 2000) and very short duration impulsive (Finneran et al., 2002) sounds are capable of causing TTS, although the sound levels required for the impulsive sounds to do so were much higher than the 1 second tonal signals. Combining her research results along with other cited studies, Cook (2006) generally found that captive animals showed more hearing loss than similar-aged free-ranging dolphins. TTS and PTS are thought to have very similar effects on marine mammals as masking: reduction in foraging efficiency, reproductive potential, social cohesion, and ability to detect predators.

Hearing damage can kill indirectly, as in the case of humpback whales found fatally entangled in fishing gear at the same time and place as underwater explosions were occurring (Todd et al., 1996). Humpback whales in the area displayed no avoidance or behavioral reactions to the explosions, yet an unusual pattern of fatal entanglement occurred, suggesting hearing damage (if whales use sound to passively detect nets) or some other compromise to their navigation or sensory systems. Based on a good baseline of typical whale entrapment rates and patterns, it was found that entrapment rates both at the time and in the nearby area of blasting were dramatically and significantly higher, even though there were fewer fishing nets in the area (Todd, Stevick, Lien, Marques, & Ketten, 1996). Additionally, re-entrapments of the same animals occurred, something that had not happened for the previous 15 years. It is important to note that, based on the

whales' behavior, one would have incorrectly concluded that the explosions did not impact the animals, were it not for the special case of higher and unusual entanglement rates or patterns.

Noise and Stress

Although several reviews have entertained the possibility that noise induces a physiological stress response in marine mammals, there have been few studies. Romano et al. (2004) exposed a captive beluga whale and bottlenose dolphin to sounds from a seismic water gun and (for the bottlenose dolphin) 1-s, 3-kHz pure tones. They looked for various hormones in the blood, including cortisol, before and after exposure and saw changes (especially with the seismic sound) that were considered detrimental. These changes increased with increasing sound levels, and were significant. Thomas, Kastelein, & Awbrey (1990), however, did not find elevated stress hormone levels in the blood after playbacks of oil drilling platform noise to captive belugas, though their measures were less sensitive than those used in Romano et al. (2004). Miksis et al. (2001) found that heart rate in a captive bottlenose dolphin increased in response to threat sounds produced by other dolphins.

Context and Consequence

There can be great variation in the reaction of marine mammals to noise, depending on such factors as species, individual, age, sex, prior experience with noise, and behavioral state. Species with similar hearing capabilities can respond differently to the same noise (IWC, 2007). There are many documented cases of apparent tolerance of marine mammals to noise, which also demonstrate much variability. For example, bowhead whales tolerated an increase in 40 dB in seismic survey noise when feeding in summer than during the fall migration, where broadband received levels of airgun pulses corresponding to avoidance were 120–130 dB re 1 µPa (rms over pulse duration) and above (Richardson et al., 1995, Richardson, Miller, & Greene, 1999). Other examples of apparent tolerance can be found in sperm whales with seismic surveys in Norway (Madsen, Møhl, Nielsen, & Wahlberg, 2002), blue (*Balaenoptera musculus*) and fin whales with LFA sonar (Croll et al., 2001) and sea lions (*Zalophus californianus*) to AHDs (NMFS, 1996). It is not known what the consequences of this apparent tolerance are: it may represent acclimation or habituation of some kind, but may also represent an unrelenting need, e.g. for feeding or reproduction, to remain in a particular location despite exposure to noise, that could result in increased impacts from masking, hearing loss, and other potential effects, such as stress.

The observed reactions to noise in marine mammals could theoretically result in impacts such as decreased foraging efficiency, higher energetic demands, less group cohesion, higher predation, decreased reproduction, and other effects, thus seriously impacting the population as well as the individual. Alternatively, they may be harmless. However, noise is thought to contribute to at least some

species' declines or lack of recovery (Southern resident killer whales, Sakhalin gray whales; NMFS, 2002; IWC, 2007).

References

Balcomb, K. C., & Claridge, D. E. (2001). A mass stranding of cetaceans caused by naval sonar in the Bahamas. *Bahamas Journal of Science*, **8***(2)*, 1-8.

Bejder, L. (2005*). Linking short and long-term effects of nature-based tourism on cetaceans*. (Ph.D. thesis, Dalhousie University, Nova Scotia, Canada).

Bryant, P. J., Lafferty, C. M., & Lafferty, S. K. (1984). Reoccupation of Guerrero Negro, Baja California, Mexico, by gray whales. In M. L. Jones, S. L. Swartz, & S. Leatherwood (Eds.), *The gray whale, Eschrichtius robustus* (pp. 375-87). Orlando: Academic Press.

Bowles, A. E., Smultea, M., Würsig, B., DeMaster, D. P., & Palka, D. (1994). Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. *Journal of the Acoustical Society of America*, **96**, 2469-2484.

Buckstaff, K. C. (2004). Effects of watercraft noise on the acoustic behavior of bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. *Marine Mammal Science*, **20***(4)*, 709-725.

Claridge, D. E. (2006). *Fine-scale distribution and habitat selection of beaked whales*. (M.Sc. thesis, University of Aberdeen, Scotland). 119 pp.

Cook, M. L. H. (2006). *Behavioral and Auditory Evoked Potential (AEP) hearing measurements in odontocete cetaceans*. (Ph.D. dissertation, University of South Florida, St. Petersburg). 123 pp.

Cosens, S. E., & Dueck, L. P. (1993). Ice breaker noise in Lancaster Sound, NWT, Canada: implications for marine mammal behavior. *Marine Mammal Science*, **9***(3)*, 285-300.

Costa, D. P., Crocker, D. E., Gedamke, J., Webb, P. M., Houser, D. S., Blackwell, S. B., Waples, S., Hayes, S. A., & LaBouef, B. J. (2003). The effect of a low-frequency sound source (acoustic thermometry of the ocean climate) on the diving behaviour of juvenile northern elephant seals, *Mirounga angustirostris. Journal of the Acoustical Society of America*, **113***(2)*, 1155-1165.

Cox, T. M., Ragen, T. J., Read, A. J., Vos, E., Baird, R. W., Balcomb, K., et al.(2006). Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management*, **7***(3)*, 177-187.

Croll, D. A., Clark, C. W., Calambokidis, J., Ellison, W. T., & Tershy, B. R. (2001). Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. *Animal Conservation*, **4**, 13-27.

Croll, D. A., Clark, C. W., Acevedo, A., Tershy, B., Flores, S., Gedamke, J., & Urban, J. (2002). Only male fin whales sing loud songs. *Nature (London)*, **417**, 809.

Fernández, A., Edwards, J. F., Rodríguez, F., Espinosa de los Monteros, A., Herráez, P., Castro, P., Jaber, J. R., Martín, V., & Arbelo, M. (2005). 'Gas and fat embolic syndrome' involving a mass stranding of beaked whales (family *Ziphiidae*) exposed to anthropogenic sonar signals. *Veterinary Pathology*, **42**, 446-457.

Finley, K. J., Miller, G. W., Davis, R. A., & Greene, C. R. (1990). Reactions of belugas, *Delphinapterus leucas*, and narwhals, *Monodon monoceros*, to ice-breaking ships

in the Canadian high arctic. *Canadian Bulletin of Fisheries and Aquatic Sciences*, **224,** 97-117.

Finneran, J. J., Schlundt, C. E., Dear, R., Carder, D. A., & Ridgway, S. H. (2002). Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *Journal of the Acoustical Society of America*, **111***(6)*, 2929–2940.

Foote, A.D., Osborne, R.W., & Rus Hoelzel, A. (2004). Whale-call response to masking boat noise. *Nature (London)*, **428**, 910.

Harrington, F. H., & Veitch, A. M. (1992). Calving success of woodland caribou exposed to low-level jet fighter overflights. *Arctic*, **45**, 213-218.

Hatch, L. & Wright, A. J. (2007). A brief review of anthropogenic sound in the oceans. *International Journal of Comparative Psychology*, **this issue**, 121-133.

Hildebrand, J. A. (2005). Impacts of anthropogenic sound. In J. E. Reynolds, III, W. F. Perrin, R. R. Reeves, S. Montgomery, & T. J. Ragen (Eds.), *Marine mammal research: conservation beyond crisis* (pp. 101-124). Baltimore: Johns Hopkins University Press.

ICES (International Council for the Exploration of the Sea). (2005). Report of the Ad-hoc Group on the Impact of Sonar on Cetaceans and Fish (AGISC). ICES CM 2005/ACE:01, 41 pp.

IWC (International Whaling Commission). (2005). Report of the Scientific Committee. Annex K. Report of the Standing Working Group on Environmental Concerns. *Journal of Cetacean Research and Management, (Suppl)* **7**, 267-305.

IWC (International Whaling Commission). (2007). Report of the Scientific Committee. Annex K. Report of the Standing Working Group on Environmental Concerns. *Journal of Cetacean Research and Management, (Suppl)* **9**, 227-296.

Jones, M. L., Swartz, S. L., & Dahlheim, M. E. (1994). Census of gray whale abundance in San Ignacio Lagoon: a follow-up study in response to low whale counts recorded during an acoustic playback study of noise effects on gray whales. Report to the U.S. Marine Mammal Commission, Washington, DC. NTIS PB94195062. 32 pp.

Lesage, V., Barrette, C., Kingsley, M. C. S., & Sjare, B. (1999). The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence River Estuary, Canada. *Marine Mammal Science*, **15***(1)*, 65-84.

Madsen, P. T., Møhl, B., Nielsen, B. K., & Wahlberg, M. (2002). Male sperm whale behaviour during exposures to distant seismic survey pulses. *Aquatic Mammals*, **28***(3)*, 231-240.

Malme, C. I., Miles, P. R., Clark, C. W., Tyack, P., & Bird, J. E. (1983). Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. Report of Bolt Beranek & Newman, Inc., Cambridge, MA, to U.S. Minerals Management Service, Anchorage. NTIS PB86-174174.

Malme, C. I., Miles, P. R., Clark, C. W., Tyack, P., & Bird, J. E. (1984). Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. Phase II: January 1984 migration. Report of Bolt Beranek & Newman, Inc., Cambridge, MA, to U.S. Minerals Management Service, Anchorage. NTIS PB86-218377.

MMC (Marine Mammal Commission). (2007). Marine mammals and noise: A sound approach to research and management. 370 pp. Available at: http://www.mmc.gov/sound/committee/pdf/soundFACAreport.pdf

McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M. N., Penrose, J., Prince,

R. I. T., Adhitya, A., Murdoch, J., & McCabe, K. (2000). Marine seismic surveys—a study of environmental implications. APPEA J. **40**, 692-708.

Miksis, J. L., Grund, M. D., Nowacek, D. P., Solow, A. R., Connor, R. C., & Tyack, P. L. (2001). Cardiac responses to acoustic playback experiments in the captive bottlenose dolphin (*Tursiops truncatus*). *Journal of Comparative Psychology*, **115***(3)*, 227-232.

Miller, P. J. O., Biasson, N., Samuels, A., & Tyack, P. L. (2000). Whale songs lengthen in response to sonar. *Nature (London)*, **405**, 903.

Morton, A. B., & Symonds, H. K. (2002). Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia. *ICES Journal of Marine Sciences*, **59**, 71-80.

NMFS (National Marine Fisheries Service). (1996). Environmental assessment on conditions for lethal removal of California sea lions at the Ballard Locks to protect winter steelhead. NMFS Environmental Assessment Report. 81 pp. Available from Northwest Regional Office, NMFS, NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

NMFS (National Marine Fisheries Service). (2002). Status review under the Endangered Species Act: Southern Resident Killer Whales (*Orcinus orca*). NOAA (National Oceanographic and Atmospheric Administration) Tech. Memo. NMFSNWAFSC-54, Seattle, Washington: NMFS. 131 pp.

NOAA (National Oceanographic and Atmospheric Administration) & U.S. Department of the Navy. (2001). Joint Interim Report: Bahamas Marine Mammal Stranding Event of 15-16 March 2000. Washington, D.C.: U.S. Department of Commerce, 59 pp.

Nowacek, D. P., Thorne, L. H., Johnston, D. W., & Tyack, P. L. (2007). Responses of cetaceans to anthropogenic noise. Mammalian Review, **37***(2)*, 81-115.

Rendell, L. E., & Gordon, J. C. D. (1999). Vocal response of long-finned pilot whales (*Globicephala melas*) to military sonar in the Ligurian Sea. *Marine Mammal Science*, **15***(1)*, 198-204.

Richardson, W. J., Fraker, M. A., Würsig, B., & Wells, R. S. (1985). Behavior of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: Reactions to industrial activities. *Biological Conservation*, **32***(3)*, 195-230.

Richardson, W. J., Würsig, B., & Greene, C. R., Jr. (1986). Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. *Journal of the Acoustical Society of America*, **79***(4)*, 1117-1128.

Richardson, W. J., Würsig, B., & Greene, C. R., Jr. (1990). Reactions of bowhead whales, *Balaena mysticetus*, to drilling and dredging noise in the Canadian Beaufort Sea. *Marine Environmental Research*, **29***(2)*, 135-160.

Richardson, W. J., Greene, C. R., Jr., Malme, C. I., & Thomson, D. H. (1995*). Marine mammals and noise*. New York: Academic Press, 576 pp.

Richardson, W. J., Miller, G. W., & Greene, C. R. (1999). Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. *Journal of the Acoustical Society of America*, **106**, 228 (abstract only).

Romano, T. A., Keogh, M. J., Kelly, C., Feng, P., Berk, L., Schlundt, C. E., Carder, D. A., & Finneran, J. J. (2004). Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. *Canadian Journal of Fisheries and Aquatic Sciences*, **61**, 1124-1134.

Scheifele, P. M., Andrew, S., Cooper, R. A., Darre, M., Musiek, F. E., & Max, L. (2005). Indication of a Lombard vocal response in the St. Lawrence River beluga. *Journal*

of the Acoustical Society of America, **117***(3)*, 1486-1492.

Schlundt, C. E., Finneran, J. J., Carder, D. A., & Ridgway, S. H. (2000). Temporary shift in masked hearing thresholds (MTTS) of bottlenose dolphins and white whales after exposure to intense tones. *Journal of the Acoustical Society of America*, **107**, 3496-3508.

Soto, N. A., Johnson, M., Madsen, P. T., Tyack, P. T., Bocconcelli, A., & Borsani, J. F. (2006). Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? *Marine Mammal Science*, **22***(3)*, 690-699.

Stone, C. J., & Tasker, M. L. (2006). The effect of seismic airguns on cetaceans in UK waters. *Journal of Cetacean Research and Management*, **8***(3)*, 255-263.

Taylor, B.L., Martinez, M., Gerrodette, T., Barlow, J., & Hrovat, Y. N. (2007). Lessons from monitoring trends in abundance of marine mammals. *Marine Mammal Science*, **23***(1)*, 157-175.

Thomas, J. A., Kastelein, R. A., & Awbrey, F. T. (1990). Behavior and blood catecholamines of captive belugas during playbacks of noise from an oil drilling platform. *Zoo Biology*, **9**, 393-402.

Todd, S., Stevick, P., Lien, J., Marques, F., & Ketten, D. (1996). Behavioural effects to underwater explosions in humpback whales (*Megaptera novaeangliae). Canadian Journal of Zoology*, **74**, 1661-1672.

Tyack, P. L., & Clark, C. W. (1998). Quick-look report: playback of low-frequency sound to gray whales migrating past the central California coast. Unpublished Report. Available from the National Marine Mammal Laboratory (nmml.library@noaa.gov).

Watkins, W. A. (1986). Whale reactions to human activities in Cape Cod waters. *Marine Mammal Science*, **2**, 251-262.

Watkins, W. A., & Schevill, W. E. (1975). Sperm whales (*Physeter catodon*) react to pingers. *Deep-Sea Research*, **22**, 123-129.

Watkins, W. A., Moore, K. E., & Tyack, P. (1985). Sperm whale acoustic behaviors in the southeast Caribbean. *Cetology*, **49**, 1-15.

Whitehead, H., Reeves, R. R., & Tyack, P. L. (2000). Science and the conservation, protection, and management of wild cetaceans. In J. Mann, R. C. Connor, P. L. Tyack, & H. Whitehead (Eds.), *Cetacean societies* (pp. 308-332). Chicago, Ill.: University of Chicago Press.

Wimmer, T., & Whitehead, H. (2004). Movements and distribution of northern bottlenose whales, *Hyperoodon ampullatus*, on the Scotian Slope and in adjacent waters. *Canadian Journal of Zoology*, **82***(11)*, 1782-1794.

International Journal of Comparative Psychology, 2007, **20**,169-178.
Copyright 2007 by the International Society for Comparative Psychology

Environmental Noise and Decision Making Possible Implications of Increases in Anthropogenic Noise for Information Processing in Marine Mammals

Melissa Bateson
Newcastle University, United Kingdom

Recent increases in anthropogenic noise in the marine environment are a source of concern for the current welfare and future fitness of many marine mammal species. In this article I explore the specific question of how environmental noise could affect information processing. I also discuss the possible changes in behavior that would result, and how these changes could negatively impact the welfare and fitness of marine mammals. I identify two ways in which environmental noise could affect decision-making. First, environmental noise could add statistical noise to the detection of auditory signals, either masking them completely or rendering them ambiguous. Animals can respond to this problem either by moving away from the source of noise, or by altering the characteristics of their signal processing to increase the signal to noise ratio. Second, environmental noise could generate emotional states of fear or anxiety that cause biases in information processing. Anxiety is an emotion that functions as an early warning of potential threats, and is associated with a suite of changes in information processing including sensitization to stimuli potentially associated with threats, and pessimistic biases in decision-making resulting in increased risk aversion. Although these changes are clearly beneficial in the short term, chronic anxiety is likely to result in behavioral changes that will be detrimental to an animal's fitness in the longer term. Thus, there are likely to be subtle effects of noise on decision-making that have not so far been considered in relation to the effects of anthropogenic noise on marine mammal behavior.

The Problem

Anthropogenic noise has increased dramatically in the marine environment in recent years (Andrew, Howe, Mercer, & Dzieciuch, 2002; Hatch & Wright, this issue), and it is therefore important to consider how this change could affect the welfare and fitness (i.e. lifetime reproductive success) of marine mammals (Fair & Becker, 2000; Wright et al., this issue, b). Environmental noise can potentially impact the welfare and fitness of animals via a number of different mechanisms. For example, loud noises can directly damage animals' ears, and chronic exposure to moderate levels of environmental noise is associated with physiological and anatomical changes in both rats and humans that are associated with negative health consequences (Baldwin, this issue; Clark & Stansfeld, this issue; Wright et al., this issue, a). Environmental noise may also have less direct effects on behavior, and possibly also fitness, by causing alterations in information processing and consequent decision-making. These latter effects may be subtler than the direct effects of noise, however through the alterations in behavior that they cause they could be equally detrimental to animal welfare and long-term fitness. In the remainder of this article I will describe and discuss some of the effects of

I would like to thank Dieter Paulmann and Dokumente des Meeres for inviting me to participate in their workshop on noise-related stress in marine mammals, Andrew Wright for coordinating the writing of the report, Jo Hastie for making our trip to Lanzarote so enjoyable, and helpful comments on the manuscript from two anonymous referees. The Royal Society and BBSRC for financial support for my research on animal welfare and decision-making. Correspondence concerning this article should be addressed to Melissa Bateson, Centre for Behaviour and Evolution, Henry Wellcome Building for Neuroecology, Framlington Place, Newcastle upon Tyne, NE2 4HH, U.K. (Melissa.Bateson@ncl.ac.uk).

noise on information processing. I should stress at this point that there is currently very little information about these effects in marine mammals, and consequently the majority of my examples will come from studies of other more easily studied animals such as laboratory rodents and birds. However, there is every reason to expect that marine mammals should respond in similar ways to other animals when confronted with increases in environmental noise, and the limited information that we do currently have for marine mammals supports this prediction (Wright et al., this issue, b).

Information Processing and Noise

The performance of adaptive behavior relies on an animal possessing accurate information about the world (Dall, Giraldeau, Olsson, McNamara, & Stephens, 2005). Natural selection has equipped animals with the cognitive mechanisms that they need to process information and generate adaptive behavior within the environments in which they have evolved. The brain receives information about the state of the environment via the senses and about the state of the body via its own internal monitoring mechanisms. On the basis of this information, decision mechanisms in the brain generate appropriate physiological and behavioral responses.

Sound is an extremely important source of information for marine animals. The superior propagation of sound in water as compared with air, coupled with reduced visibility in the sea have led to hearing becoming an important sense in many species of marine mammals and probably also fish. For example, many marine mammals use vocalizations for both intra-specific communication and for echolocation, meaning that auditory information is crucial to activities including locating food, making foraging decisions, avoiding predators, choosing mates and social behavior. As a consequence of the importance of sound in marine mammal ecology, it makes sense that marine mammals have evolved specialized mechanisms for processing sound-related information, and that these mechanisms might be particularly sensitive to changes in environmental noise.

The term information processing refers to everything that goes on between information entering an animal via its sense organs and observed behavior (see Figure 1 for a summary). Thus, the brain can be viewed as an information-processing organ. I will discuss two routes via which environmental noise could potentially alter information processing in marine mammals.

First, environmental noise could add statistical noise to the detection of auditory signals, masking the incoming information completely, changing it in some way, or rendering it ambiguous. Second, by generating an emotional state, such as fear or anxiety, environmental noise could provoke changes in decision-making mechanisms congruent with the induced state. Below I enlarge on each of these possibilities and provide examples of the changes in behavior that might result.

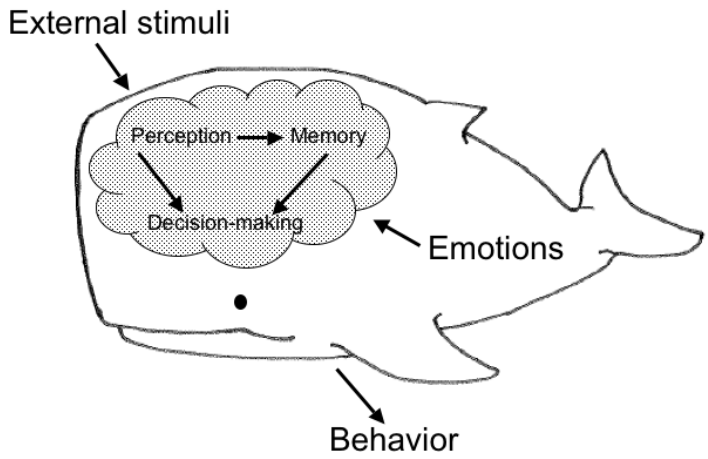


Figure 1. The basic elements of an information-processing model of behavior. Environmental noise could affect information processing in animals either by interfering with the in-coming information from the environment, or indirectly, by evoking internal emotional states such as anxiety that then bias information processing mechanisms.

Detecting Signals in Noise

Many animals face the problem of distinguishing biologically important stimuli, such as conspecific signals or returning echoes, from background noise (for a review see Brumm & Slabbekoorn, 2005). Some mistakes are inevitable, because most signals have some degree of variation associated with them, and natural environments are characterized by permanent background noise of biotic and abiotic origins. Figure 2 illustrates a typical signal detection problem in which an animal looking for a potential mate is faced with distinguishing conspecific calls from those of other species. Although I have chosen this particular example, it is important to realize that the same basic scenario could apply to discriminating any type of auditory information from background noise including returning echoes, sounds of other species and abiotic noises such as those produced by weather, seismic activity and boats. In Figure 2 both types of call are somewhat variable in frequency, as depicted by the normal distributions, and there is an area of overlap in which the two types of call cannot be distinguished on the basis of frequency alone. As a result, conspecific signals will sometimes be incorrectly ignored (misses) and calls of other species will sometimes be incorrectly identified as conspecifics (false alarms, see Table 1). Both types of mistakes have associated costs; in this example, misses will result in passing up a potential mate, whereas false alarms will result in time waste courting the wrong species and possibly infertile mating attempts. In different scenarios the costs will be different; for example in the situation where an animal has to detect the sound of an approaching boat from background environmental noise a miss could result in physical injury or even death, and a false alarm could result in prematurely leaving a good foraging patch.

The problem faced by natural selection is how to minimize the costs of misses and false alarms. Signal detection theory, originally developed in a military context to deal with the problem of identifying significant objects such as planes on noisy radar screens, can be used to quantify this trade-off (e.g. Wiley, 1994). In short, the position of the criterion for discriminating the two

types of call will depend on the relative costs of the two types of mistakes: if misses are cheap or false alarms particularly costly then it will pay to set a conservative criterion (i.e. further towards the right) and only initiate mating or stop foraging if the sound is highly characteristic of a conspecific vocalization or a boat engine, whereas if the reverse is true and misses are costly or false alarms cheap, then it will pay to set a less stringent criterion (i.e. further towards the left) and classify a wider range of signals as those of potential mates or dangerous boats. The optimal position for the criterion will depend on the specific context and the relative costs and benefits of errors versus correct responses.

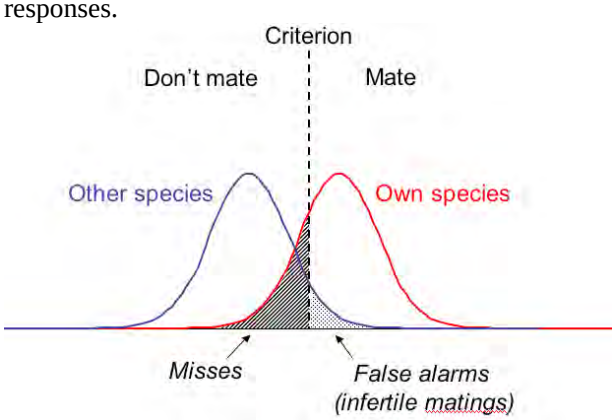


Figure 2. In this example, the x-axis describes the frequency of a call, and the y-axis describes the probability of a call of a given frequency appearing. Two probability distributions are shown: the one on the left corresponds to the calls of other species, and the one on the right to conspecific calls. The dotted line is the criterion below which calls are classified as other species and above which calls are classified as conspecific. The probability of missing a conspecific call is indicated by the hatched area, and probability of a false alarm by the shaded area.

Table 1
Types of possible response in a signal detection task.

	Signal	
Response	Present	Absent
Signal detected	Hit	False alarm
No signal detected	Miss	Correct rejection

We can use the basic framework established above to think about the possible effects of increased environmental noise on decision-making. Figure 3a shows a hypothetical example in which additional environmental noise increases the variance of the distribution of signals that should be rejected. If the criterion for rejection is unchanged (as shown in Figure 3a), then the number of misses will remain unchanged, but the number of false alarms will increase. The fitness consequences of such a change will depend on the costs of a false alarm, but if, as in the case of the above example, a false alarm translates into an infertile mating, then they could be considerable. In the most extreme cases environmental noise could completely mask biologically significant signals depriving animals of sources of information vital for their fitness.

Animals faced with an increase in environmental noise can respond in various ways to reduce the probability of errors in signal detection. Broadly speaking, either signalers can alter some aspect of their signal production to reduce the probability of errors, or signal receivers can change some feature of

their signal to reduce the probability of errors. In both cases these responses could either be adaptive plasticity within the individual, or take place by natural selection over evolutionary time. However, the long life spans and generation times of many marine mammal species may severely limit their capacity to keep up with rapid environmental changes via the latter mechanism.

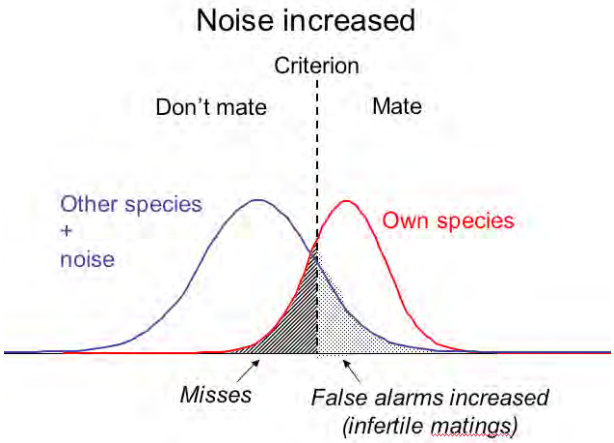


Figure 3a. Increased environmental noise makes the signal detection problem described in Figure 2 more difficult by increasing the variance of the sounds from which conspecific calls must be discriminated.

Hearing may initially appear a passive sense in which the signal receiver has little latitude for improving signal detection. However, there are a number of mechanisms involving both perception and behavior via which signal receivers can reduce the probability of errors in detection. At the behavioral level, it may be possible to improve the signal to noise ratio by moving closer to the source of a signal or away from the source of noise. At the information processing level, the signal receiver could change the criterion for classification. For example, moving the criterion to the right will serve to reduce the false alarm rate at the expense of increasing the miss rate (Figure 3b). Many perception adaptations have also been identified in species as diverse as insects, frogs, birds and bats (reviewed in Brumm & Slabbekoorn, 2005). Research on perception is usually derived from laboratory studies, making it difficult in marine mammals, however recent research on hearing in fish under noise conditions has the potential to identify the strategies used in fish (Wysocki & Ladich, 2005).

Signalers can respond by shifting the signal away from the noise by altering its frequency (Figure 3c), or sharpening the discriminability of the conspecific signal (Figure 3d), which will reduce the number of misses. An example of altering the frequency of a signal is found in urban great tits (*Parus major*), in which a correlation is observed between the amplitude of background noise and the average minimum frequency of male birds' songs (Slabbekoorn & Peet, 2003). Animals have used a number of different strategies for improving the discrimination of a signal without changing its frequency. Perhaps the most obvious way to counteract the masking effects of background is to increase the amplitude, a response referred to as the "Lombard effect". There is abundant evidence that many birds sing louder in response to increases in background noise. For example, male nightingales

(*Luscinia megarhynchos*) regulated the intensity of their songs according to the level of masking noise, thus maintaining a specific signal-to-noise ratio that is favorable for communication (Brumm & Todt, 2002). Another approach is to increase the duration of the signal or repeat the same signal more often. For example, killer whales (*Orcinus orca*) produced more easily perceived, long calls when noise from boats exceeded a threshold level (Foote, Osborne, & Hoelzel, 2004), and beluga whales (*Delphinapterus leucas*) increased the repetition of specific calls when a boat was nearby (Lesage, Barrette, Kingsley, & Sjare, 1999). It is important to realize that these compensatory strategies are not likely to be without cost. In the case of the killer whales for example, making longer calls must take either time or attention away from other important activities such as foraging, and will involve an increased energetic cost.

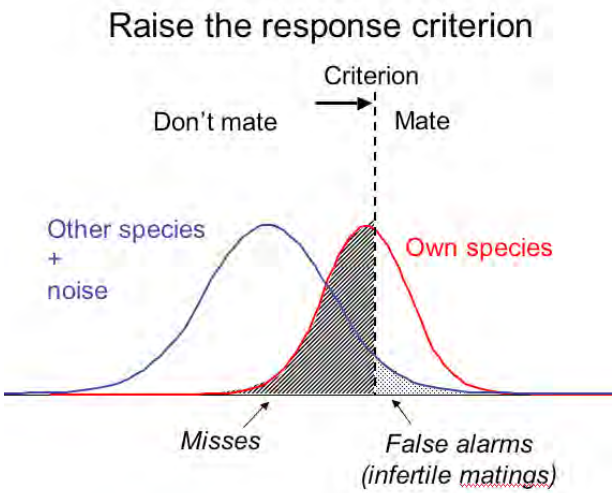


Figure 3b. Animals might respond to increased environmental noise by shifting the criterion to the right and hence reducing the possibility of false alarms at the expense of increasing the probability of misses.

Finally, both signalers and signal receivers can attempt to escape increased environmental noise either spatially or temporally. Spatial escape would involve moving to a different location where environmental noise is reduced. It is now well established that whales choose to avoid areas of high whale watching activity, and one explanation for this preference could lie in the signal detection difficulties imposed by boat noise (Wright et al., this issue, b). A major cost of using a spatial avoidance strategy is that it is likely to force animals into areas that are otherwise suboptimal. For example, whales might be forced into less good foraging areas in order to escape anthropogenic noise, which is likely to have welfare and fitness consequences. Temporal escape involves altering the timing of signaling to correspond with the time when there is least environmental noise. An example of this latter strategy was recently reported in urban robins that have shifted to singing during the night in areas where there is high traffic noise during the day (Fuller, Warren, & Gaston, 2007). Again, it is unlikely that this strategy will be without cost, because by singing at night robins may be exposing themselves to increased predation risks or depriving themselves of sleep. A possible case of temporal escape has been described in beluga whales (*Delphinapterus leucas*) that reduce their calling rate while vessels are approaching (Lesage, Barrette,

Kingsley, & Sjar, 1999). It is hard to speculate about the possible costs of this change in behavior without knowing the precise function of the vocalizations involved.

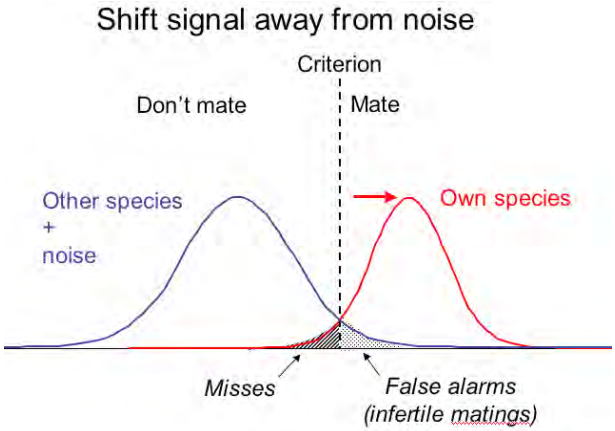


Figure 3c. Animals might respond to increased environmental noise by shifting their own signals away from the noise hence reducing the number of misses.

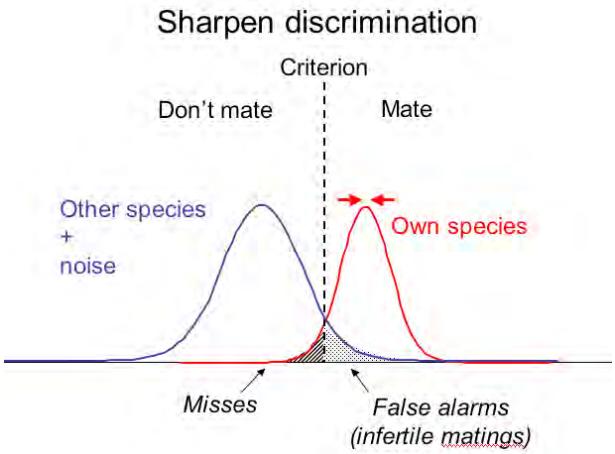


Figure 3d. Animals might respond to increased environmental noise by sharpening the discrimination of their own signals. This could be affected by reducing the variance in conspecific calls. The effect is to reduce the number of misses.

Cognitive Bias and Noise

For many animals environmental noise is an important cue that danger could be imminent. For example, many animals will rely on sound to provide them with information about the possible approach of a predator or other threat. It therefore makes sense that many animals will respond to unusual or unexpected noises with adaptive emotional reactions such as fear and anxiety. Increased levels of background noise are also associated with a stress response in humans (Clark & Stansfeld, this issue). Anxiety is an emotion that functions as an early warning of potential threats, and is associated with a suite of changes that prepare the animal for dealing with the threat. The physiological and behavioral changes that come with anxiety such as increased heart rate and vigilance are well known, however these are also accompanied by changes in information processing, referred to as "cognitive biases", that prepare the

animal cognitively for dealing with the threat (Clore & Huntsinger, 2007; Mathews, Mackintosh, & Fulcher, 1997). For example, anxious humans show selective attention to threatening words (Williams, Mathews, & McLeod, 1996), and will detect an angry face amongst a large array of neutral faces more rapidly (Bryne & Eysenck, 1995). Anxious humans are also more likely to assume a negative or threatening interpretation when presented with ambiguous stimuli such as homophones (e.g. die/dye or pain/pane, (Eysenck, MacLeod, & Matthews, 1987; Eysenck, Mogg, May, Richards, & Matthews, 1991)).

Recently, "pessimistic" cognitive biases have also been reported in non-human animals housed in suboptimal cages. For example, Harding et al. (2004) trained rats on a go/no-go task to press a lever to obtain a food reward on hearing a positive stimulus (the food-delivery tone), but to refrain from pressing the lever to avoid unpleasant white noise on hearing a negative stimulus (the noise-avoidance tone). Once trained on this task, rats were allocated to either predictable or unpredictable (depression-inducing) housing. Following this manipulation the rat were tested with non-reinforced stimuli intermediate between the food-delivery and noise-avoidance tones. The animals' anticipation of the positive and negative outcomes was estimated by measuring the probability with which they lever-pressed in response to the ambiguous tones. Rats in the unpredictable group showed fewer and slower responses than rats in the predictable group. Thus, the depressed rats showed reduced anticipation of a positive event.

We used a similar approach to ask whether European starlings (*Sturnus vulgaris*) deprived of environmental enrichment in their cages show biases in their classification of ambiguous signals (Bateson & Matheson, 2007). On the basis of the previous findings in humans and rats discussed above, we hypothesized that starlings in enriched cages should be more likely to classify ambiguous signals as being associated with a positive outcome than starlings housed in standard, unenriched cages. Starlings were trained on a go/no-go procedure to discriminate between two visual stimuli (cardboard lids of white and dark grey) associated with outcomes of a different value (palatable and unpalatable mealworms hidden underneath). Individual birds' responses to unreinforced, intermediate stimuli (various shades of grey between white and dark grey) were subsequently examined while each bird was housed sequentially in both standard and enriched cages. The probability of a bird classifying an ambiguous pale grey lid as hiding a palatable mealworm was lower in standard cages than enriched cages, but this difference was only found in birds that received enriched cages first (Figure 4). Our results can be interpreted as showing a pessimistic bias in birds that have recently experienced a decline in environmental quality (see also Matheson, Asher & Bateson, 2008).

The above studies show that animals experiencing anxiety or depression induced by poor housing conditions are more pessimistic in their interpretation of ambiguous information resulting in more risk-averse decision-making. The pessimistic animals were less ready to expose themselves to unpleasant events such as white noise or quinine-tainted food. It is reasonable to hypothesize that similar risk-averse biases may be present in marine mammals rendered anxious by recent increases in anthropogenic noise. While increased risk-aversion is an adaptive response in the face of real threats,

chronic pessimism is unlikely to be adaptive since it may cause animals to pass up opportunities beneficial to their long-term fitness.

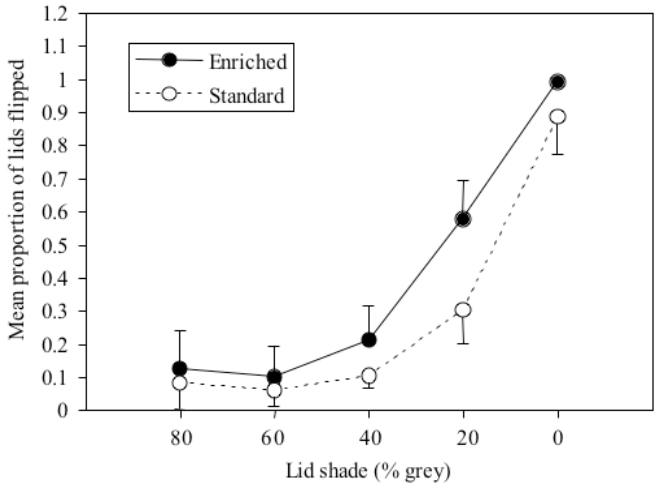


Figure 4. An example of a pessimistic cognitive bias . The x-axis shows the shade of the lid used to hide a worm. 80% grey lids were associated with unpalatable quinine-injected mealworms whereas white lids (i.e. 0% grey) were associated with palatable mealworms. Intermediate lid shades were never reinforced with either type of mealworm. The y-axis shows the proportion of times birds investigated Petri dishes by flipping off the lid (from Bateson & Matheson (2007), with permission).

Conclusions

Increases in anthropogenic noise are likely to have subtle effects on the cognition and behavior of marine mammals via at least two different mechanisms. First, noise may interfere with or mask the auditory signals available to marine mammals depriving them of important sources of information. Although evidence suggests that animals will compensate for such interference via a range of strategies, this is unlikely to be without costs. Second, noise may evoke emotional states that bring about biases in information processing and decision-making. Although these biases may have been adaptive in the environments in which the animals evolved, it is possible that they may be maladaptive in the radically different environments present in today's oceans. Further research is needed to identify the extent to which marine mammal behavior is affected by increased levels of anthropogenic noise, and to quantify the potential welfare and fitness consequences of these changes.

References

Andrew, R. K., Howe, B. M., Mercer, J. A., & Dzieciuch, M. A. (2002). Ocean ambient sound: Comparing the 1960s with the 1990s for a receiver off the Californian coast. *Acoustic Research Letters Online* **3**, 65-70.

Baldwin, A. L. (2007). Effects of noise on rodent physiology. *International Journal of Comparative Psychology*, **this issue**, 134-144.

Bateson, M. & Matheson, S. M. (2007). Removal of environmental enrichment induces 'pessimism' in captive European starlings (*Sturnus vulgaris*). *Animal Welfare*, **16**(S), 33-36.

Brumm, H. & Slabbekoorn, H. (2005). Acoustic communication in noise. *Advances in the Study of Behavior*, **35**, 151-209.

Brumm, H. & Todd, D. (2002). Noise dependent song amplitude regulation in a territorial songbird. *Animal Behaviour*, **63**, 891-897.

Bryne, A., & Eysenck, M. W. (1995). Trait anxiety, anxious modd, and threat detection. *Cognition and Emotion*, **9**, 549-562.

Clark, C. & Stansfeld, S. A. (2007). The effect of transportation noise on health & cognitive development: A review of recent evidence. *International Journal of Comparative Psychology*, **this issue**, 145-158.

Clore, G. L., & Huntsinger, J. R. (2007). How emotions inform judgment and regulate thought. *Trends in Cognitive Sciences*, **11**, 393-399.

Dall, S. R. X., Giraldeau, L.-A., Olsson, O., McNamara, J. M., & Stephens, D. W. (2005). Information and its use by animals in evolutionary ecology. *Trends in Ecology and Evolution*, *20*, 187-193.

Eysenck, M. W., MacLeod, C., & Matthews, A. (1987). Cognitive functioning and anxiety. *Psychological Research*, **49**, 189-195.

Eysenck, M. W., Mogg, K., May, J., Richards, A., & Matthews, A. (1991). Bias in interpretation of ambiguous sentences related to threat in anxiety. *Journal of Abnormal Psychology*, **100**, 144-150.

Fair, P. A., & Becker, P. R. (2000). Review of stress in marine mammals. *Journal of Aquatic Ecosystem Stress and Recovery*, **7**, 335-354.

Foote, A. D., Osborne, R. W., & Hoelzel, A. R. (2004). Whale-call response to masking boat noise. *Nature*, **428**, 910.

Fuller, R. A., Warren, P. H., & Gaston, K. J. (2007). Daytime noise predicts nocturnal singing in urban robins. *Biology Letters*.

Harding, E. J., Paul, E. S., & Mendl, M. (2004). Cognitive bias and affective state. *Nature*, **427**, 312.

Hatch, L. & Wright, A. J. (this issue). A brief review of anthropogenic sound in the oceans. *International Journal of Comparative Psychology*, **this issue**, 121-133.

Lesage, V., Barrette, C., Kingsley, M. C. S. & Sjar, B. (1999). The effect of vessel noise on the vocal behavior of Belugas in the St. Lawrence River estuary, Canada. *Marine Mammal Science*, **15**, 65-84.

Matheson, S. M., Asher, L. & Bateson, M. (2008). Larger, enriched cages are associated with 'optimistic' response biases in captive European starlings (*Sturnus vulgaris*). *Applied Animal Behavior Science*, **109**, 374-383.

Mathews, A., Mackintosh, B., & Fulcher, E. P. (1997). Cognitive biases in anxiety and attention to threat. *Trends in Cognitive Sciences*, **1**, 340-345.

Slabbekoorn, H., & Peet, M. (2003). Birds sing at a higher pitch in urban noise. *Nature*, **424**, 267-268.

Wiley, R. H. (1994). Errors, exaggeration, and deception in animal communication. In L. A. Real (Ed.), Behavioural Mechanisms in Evolutionary Ecology (pp. 157-189). Chicago: University of Chicago Press.

Williams, J. M. G., Mathews, A., & McLeod, C. (1996). The emotional Stroop task and psychopathology. *Pychological Bulletin*, **120**, 3-24.

Wright, A. J., Aguilar Soto, N., Baldwin, A. L., Bateson, M., Beale, C., Clark, C., et al. (2007a). Anthropogenic noise as a stressor in animals: A multidisciplinary perspective. *International Journal of Comparative Psychology*, **this issue**, 251-274.

Wright, A. J., Aguilar Soto, N., Baldwin, A. L., Bateson, M., Beale, C., Clark, C., et al..(2007b). Do marine mammals experience stress related to anthropogenic noise? *International Journal of Comparative Psychology*, **this issue**, 275-317.

Wysocki, L. E. & Ladich, F. (2005). Hearing in fishes under noise conditions. *Journal of the Association for Research in Otolaryngology*, **6**, 28-36.

International Journal of Comparative Psychology, 2007, **20**, 179-193.
Copyright 2007 by the International Society for Comparative Psychology

The Influence of Metal Pollution on the Immune System A Potential Stressor for Marine Mammals in the North Sea

Antje Kakuschke and Andreas Prange
GKSS Research Centre, Institute for Coastal Research, Germany

Marine mammals of the North Sea are loaded with metal pollutants. The environmental exposure induces concentrations bioavailable to immune cells high enough to affect their function. Such an imbalance of the immune system caused by pollutants may play a significant role in the incidence of infectious diseases in marine mammals. Metals influence the function of immunocompetent cells by a variety of mechanisms. Depending on the particular metal, its speciation, concentration and bioavailability, and a number of other factors, a continuous metal exposure will result in an immunosuppression or immunoenhancement effects. Both effects were demonstrated on the cellular level in animals of the North Sea. This article reviews metal concentrations in the North and Baltic Seas particularly in tissues of marine mammals, discusses pollutants effects on health and immune functions, and underlines the still existing problem of animals living in polluted coastal areas.

The harbor (or common) seal, *Phoca vitulina*, the grey seal, *Halichoerus grypus* and the harbor porpoise, *Phocoena phocoena* are the most prominent domestic marine mammals in the Wadden Sea. Beside these species several other marine mammals occur in the Wadden Sea and adjacent North Sea as stragglers or regular visitors such as harp seal, *Phoca groenlandica*, hooded seal, *Cystophora cristata*, ringed seal, *Phoca hispida*, bearded seal, *Erignathus barbatus*, walrus, *Odobenus rosmarus*, various species of dolphins as well as large cetaceans, e.g. the minke whale, *Balaenoptera acutorostrata*, and sperm whale, *Physeter macrocephalus*. Seals living in the coastal area are strongly influenced by anthropogenic activities such as fishery, off-shore activities, habitat destruction and environmental pollution.

Since 1978 The Netherlands, Germany and Denmark have been working together on the protection and conservation of the Wadden Sea, which results in the development of the "Trilateral Monitoring and Assessment Program" (TMAP). Within this agreement the seal population is supposed to serve as a bioindicator for the Wadden Sea ecosystem. Seals are considered as indicators for medium and long-term changes in the ecosystem due to their widespread distribution over the coastal areas, their high trophic level, which results in a bioaccumulation and biomagnification of chemicals in their tissues, their long-life span and relatively late maturity including a low reproduction rate. All these factors serve to qualify harbor seals as biomarkers of chemical exposure in the Wadden Sea.

In addition, the "Seal Agreement" has been adopted, which establishes terms of research and monitoring including the monitoring of pollution and investigations on the effects of substances e.g. organochlorine compounds, metals and oil on the seal population. These terms have been specified in the "Seal Management Plan for the Wadden Sea Seal Population" which utilizes parameters such as reproduction, mortality and health status to assess the seal population and includes e.g. immunological, physiological, toxicological, pathohistological and microbiological research.

Correspondence concerning this article should be addressed to Antje Kakuschke, Max-Planck-Straße 1, 21502 Geesthacht, Germany. (antje.kakuschke@gkss.de).

The growth of the harbor seal population in the Wadden Sea was interrupted by a phocine distemper virus epizootic in 1988 and 2002. In this context, the influence of pollutants on the immune system has been repeatedly discussed.

Metals in the North and Baltic Seas

In the past, the North Sea ecosystem was highly loaded with both organic and metal pollutants introduced by various anthropogenic activities within the coastal zones. Until the middle of the eighties the yearly input of metal pollution caused by rivers, direct discharge, dumping at sea, atmospheric input and combustion at sea was around 340 tonnes Cd, 75 t Hg, 11.000 t Pb, 5.000 t Cr and 2.150 t Ni (Rachor & Rühl, 1990). A review on the pollution situation in the North Sea has been published by Kersten et al., 1988. Table 1 gives an overview of selected references dealing with environmental research on metals in the North and Baltic Sea.

Current studies have shown a diminishing trend in the input of pollutants into the ecosystem. The BLMP monitoring program (Bund-Länder-Messprogramm) confirmed this general tendency for metal pollutants, however it is necessary to consider this conclusion more detailed. The concentrations of Hg, Cd, Pb and Zn in water and sediment for example are still elevated compared to the “Background Reference Concentrations” which the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) derived for the “Greater North Sea” (Schmolke et al., 2005).

The Quality Status Report of the TMAP concluded that major reductions in the input and the concentrations of metals in the Wadden Sea occurred mainly in the late 1980s until the early 1990s and continued moderately until 2002. However, local and metal specific elevated concentrations compared to the proposed background values were still frequently investigated (Bakker, van den Heuvel-Greve, & Vethaak, 2005).

Metal body burdens in the mammals of the North and Baltic Seas

Contaminants found in various marine mammal species in the North and Baltic Seas include organochlorine pollutants (Bruhn, Kannan, Petrick, Schulz-Bull, & Duinker, 1999; Hall et al., 1999; Holsbeek et al., 1999; Kleivane, Skaare, Bjorge, Deruiter, & Reijnders, 1995; Sormo, Skaare, Jussi, Jussi, & Jenssen, 2003; Troisi et al., 2000), polybrominated diphenyl ethers (Kalantzi, Hall, Thomas, & Jones, 2005; Law, Allchin, Bennett, Morris, & Rogan, 2002), perfluorinated sulfonates (Kannan et al., 2002; Van de Vijver et al., 2004) and metals (Table 2).

Table 1
Selected studies on metal concentrations in the environment of the North and Baltic Seas.

Object of investigation	Element	Location	Reference
Fish	Cd, Cu, Hg, Pb, Zn	Baltic Sea	Perttilä et al., 1982a
Fish	Cd, Cu, Hg, Pb, Zn	Baltic Sea	Perttilä et al., 1982b
Fish	As	North Sea	Falconer et al., 1983
Water (surface water)	Al, Cd, Co, Cu, Mn, Ni	North Sea	Kremling & Hydes, 1988
Sediments	As, Cd, Cu, Hg, Pb, Zn	North Sea	Chapman, 1992
Fish, Shrimp, Mussel	Hg, Se	North Sea, Belgium	Guns & Vyncke, 1992
Fish, Mussel, Sediments	Ni	Baltic Sea Gdansk Bay	Skwarzec et al., 1994
Sediments	Ag, Al, Ca, Cd, Co, Cr, Cs, Cu, Fe, K, Li, Mg, Mn, Na, Ni, P, Pb, Rb, Sr, Zn	Baltic Sea Gdansk Bay	Szefer et al., 1996
Birds	Cd, Cu, Hg, Se, Zn	North Sea, German Bight	Wenzel et al., 1996
Fish, Birds, Sediments	Organo-Sn	Polish Coast Baltic Sea	Kannan & Falandysz, 1997
Water (dissolved fraction, particulate matter)	Cd, Co, Cu, Fe, Mn, Ni, Pb, Zn	Southern North Sea	Millward et al., 1998
Fish	Hg, Cu	North Sea	Broeg et al., 1999
Sediment	Cd, Cu, Pb, Zn	North Sea, Dutch coastal zone	Laane et al., 1999
Birds	Cd, Cr, Cu, Fe, Ni, Pb, Zn	North Sea, Belgian coast	Debacker et al., 2000
Water	Co, Cu, Fe, Zn	Baltic Sea, Skagerrak	Croot et al., 2002
Sediment, Suspended particulate matter	Al, Fe, K, Mn, Pb	North Sea, German Bight	Hinrichs et al., 2002
Water (coastal water, dissolved)	Co, Cu	Western North Sea	Achterberg et al., 2003
Sediments	Ba, Cd, Cr, Cu, Hg, Ni, Pb, V, Zn	North and Baltic Sea	Breuer et al., 2004
Asteroids, Sediments	Cd, Cu, Pb, Zn	North Sea, Southern Bight	Danis et al., 2004
Water (dissolved fraction, particulate matter, surface & deeper water)	Cd, Cu, Hg, Pb, Zn	Western and Central Baltic Sea	Dippner & Pohl, 2004
Fish	Cd, Cu, Mn, Pb	North Sea, Southern Bight	Henry et al., 2004
Asteroids	Cd, Cu, Pb, Zn	North Sea, Southern Bight	Danis et al., 2006
Mussel	Cd, Cu, Ni, Pb, Zn	German Wadden Sea	Jung et al., 2006
Air, Precipitation	Hg	North Sea Area	Wängberg et al., 2007

Table 2
Summary of studies on metal concentrations in tissues of marine mammals of the North and Baltic Seas.

Species	Organ	Element	Location	Reference
Phocoena phocoena, Lagenorhynchus albirostris	B, L, M	Cu, Hg, Pb, Zn	Denmark	Andersen & Rebsdorff, 1976
Phoca vitulina	Br, K, L	Cd, Cu, Hg, Pb, Zn	German Wadden Sea	Drescher et al., 1977
Phocoena phocoena, Phoca vitulina, Phoca hispida, Halichoerus grypus, Hyperoodon ampullatus, Delphinapterus leucas	K, L, M	Cd, Cu, Hg, Pb, Zn	North and Baltic Coasts, Germany	Harms et al., 1978
Phoca vitulina	B, Br, He, K, L, Pl, Sp	Cd, Cr, Cu, Fe, Mn, Pb, Zn	Dutch Wadden Sea	Duinker et al., 1979
Phoca vitulina	Br, K, L	Br, Hg, Se	Wadden Sea	Reijnders et al., 1980
Phocoena phocoena	Br, K, L,	Cd, Cu, Hg, Pb, Zn	Scotland	Falconer et al., 1983
Phocoena phocoena, Tursiops truncates, Halichoerus grypus, Stenella coeruleoalba	B, L, M	Cd, Cr, Cu, Hg, Ni, Pb, Zn	Irish Sea	Morris et al., 1989
Phoca vitulina	L	As, Cd, Cu, Hg, Se, Zn	Norwegian	Skaare et al., 1990
Phoca vitulina, Halichoerus grypus, Tursiops truncates, Lagenorhynchus albirostris, Lagenorhynchus acutus, Delphinus delphis, Stenella coeruleoalba	L	Cd, Cr, Cu, Hg, Ni, Pb Zn	Waters around British Isles	Law et al., 1991
Phocoena phocoena, Physeter macrocephalus, Delphinus delphis, Tursiops truncatus	K, L, M	Hg	Denmark, Belgium	Joiris et al., 1991
Phoca vitulina, Halichoerus grypus, Phoca hispida	K, L	Al, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Ni, Pb, V, W, Zn	Swedish waters	Frank et al., 1992
Phoca vitulina	H, S	Cd, Hg, Pb	German Wadden Sea	Wenzel et al. 1993
Phocoena phocoena	L	Organo-Sn	Polish Baltic Sea	Kannan & Faladysz, 1997
Phocoena phocoena, Halichoerus grypus	L	Organo-Sn	Waters around British Isles	Law et al., 1998
Physeter macrocephalus	B, K, L, M	Cd, Cr, Cu, Fe, Hg, Ni, Pb, Se, Ti, Zn	Southern North Sea	Holsbeek et al., 1999
Grampus griseus, Lagenorhynchus albirostris, Delphinus delphis, Stenella coeruleoalba, Globicephala melas, Lagenorhyncus acutus, Kogia breviceps, Mesoplodon bidens, Mesoplodon densirostris, Hyperoodon ampullatus, Balaenoptera physalus, Balaenoptera acutorostrata	L	Organo-Sn	Waters around British Isles	Law et al., 1999
Phocoena phocoena, Lagenorhyncus albirostris	K, L, M	Hg	North and Baltic Coasts, Germany	Siebert et al., 1999

Phocoena phocoena	L	Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn	England, Wales	Bennett et al., 2001
Phoca hispida	K, L, M	Cd, Hg, Pb, Se	Baltic Sea, Svalbard	Fant et al., 2001
Grampus griseus, Lagenorhynchus albirostris, Delphinus delphis, Stenella coeruleoalba, Globicephala melas, Lagenorhyncus acutus, Kogia breviceps, Mesoplodon bidens, Balaenoptera physalus, Balaenoptera acutorostrata	L	Ag, As, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Se, Zn	Waters around British Isles	Law et al., 2001
Phocoena phocoena	K, L, K	Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn	Southern Baltic Sea, Danish and Greenland coastal waters	Szefer et al., 2002
Phocoena phocoena, Phoca vitulina, Phoca hispida	B, Br, K, L, M, S,	organo-Sn	Norwegian	Berge et al., 2004
Phocoena phocoena, Phoca hispida, Halichoerus grypus, Stenella coeruleoalba	L	organo-Sn	Polish Baltic Sea	Ciesielski et al., 2004
Phocoena phocoena	K, L, M	Cd, Cu, Fe, Hg, Se, Zn	Belgium, France, Germany (North and Baltic Sea), Denmark	Das et al., 2004
Phoca vitulina	Bl	Al, As, Be, Cd, Cr, Co, Cu, Au, Fe, Pb, Mn, Mo, Ni, Pd, Pt, Se, Ag, Sn, Ti, Zn	German Wadden Sea	Kakuschke et al., 2005
Phocoena phocoena	L	Hg, organo-Sn	Danish waters	Strand et al., 2005
Phocoena phocoena, Phoca hispida, Halichoerus grypus, Stenella coeruleoalba	L	Al, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, Ga, Hg, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Se, Si, Sr, Tl, V, Zn	Polish Baltic Sea	Ciesielski et al., 2006
Phoca vitulina	Bl	Ca, Cu, Fe, K, P, Rb, S, Se, Sr, Zn	German Wadden Sea	Griesel et al., 2006
Halichoerus grypus	Bl	Al, As, Be, Cd, Cr, Co, Cu, Au, Pb, Mn, Mo, Ni, Pd, Pt, Se, Ag, Sn, Ti, V, Zn	German Wadden Sea	Kakuschke et al., 2006
Phocoena phocoena	K, L	Cd, Cu, Hg, Se, Zn	Southern North Sea	Lahaye et al., 2007
Phoca vitulina	Bl	Al, As, Be, Ca, Cd, Cr, Co, Cu, Fe, K, Pb, Mn, Mo, Ni, Pd, Pt, Rb, Se, Sn, Sr, Ti, V, Zn	German Wadden Sea	Griesel et al., 2008
Phoca vitulina	Bl	Al, As, Be, Ca, Cd, Cr, Fe, Pb, Mn, Mo, Ni, Se, Sn, Zn	German Wadden Sea	Kakuschke et al., 2008a
Phoca vitulina	Bl	Al, As, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mn, Mo, Ni, Pb, Pd, Pt, Rb, Se, Sn, Sr, Zn	German Wadden Sea	Kakuschke et al., 2008b

B=blubber, Bl=blood, Br=brain, M=muscle, L=liver, K=kidney, S=skin, Sp=spleen, He=heart, Pl=placenta, H=hair

Most studies on metal body burdens focused on the investigation of metal concentrations in the liver, kidney or muscle, i.e. tissues available only through post-mortem examination. In living animals the choice of samples is mostly restricted to blood and hair. However, because of sampling difficulties, up to now only few studies have reported values for metals in the blood of marine mammals (Baraj et al., 2001; Caurant & Amiard-Triquet, 1995; Nielsen, Nielsen, Jorgensen, & Grandjean, 2000) and in particular for pinnipeds in the North Sea (Griesel et al., 2006; Kakuschke et al., 2005, 2006). Current studies suggested relatively high metal concentrations in living seals of the North Sea compared to human blood reference values as well as local differences in metal concentrations (Griesel, Kakuschke, Siebert, & Prange, 2008). Furthermore newborn seals in the North Sea showed high body burdens of selected metals, probably caused by a transplacental transfer from the mother to fetus or through the milk during the lactation period (Kakuschke, Griesel, & Prange, 2008a).

Metal pollutants and marine mammal health

Metals and their effects on marine mammals have been reviewed by Das, Debacker, Pillet, & Bouquegneau (2003), O'Shea (1999), and Reijnders, Aguilar, & Donovan, (1999). Nevertheless, apart from metal body burden data, only limited information is available, especially on the related health effects. Hyvärinen & Sipilä (1984) found a relationship between stillbirths of ringed seal (*Pusa hispida saimensis*) pups from Finland and the Ni concentrations in hair samples. Experimental intoxication of harp seal (*Pagophilus groenlandicus*) with methyl-Hg by daily oral intake (25mg/kg) was found to result in lethargy, weight loss and finally death (Ronald, Tessaro, Uthe, Freeman, & Frank, 1977). The corresponding blood parameters indicated renal failure, uremia and toxic hepatitis. Rawson et al. (1993) found an accumulation of lipofuscin in the liver cells of stranded Atlantic bottlenose dolphins (*Tursiops truncatus*) caused by a Hg induced inhibition of the activity of digestive enzymes, which finally results in an increased number of liver diseases. In a case study Shlosberg et al. (1997) described progressive liver damage and finally death of a bottlenose dolphin resulting from Pb intoxication. Studies on the adrenal and testicular steroidogeneses in the grey seal (*Halichoerus grypus*) and harp seals (*Pagophilus groenlandicus)* indicated altered biosyntheses caused by metal contaminants (Freeman, Sangalang, Uthe, & Ronald, 1975; Freeman & Sangalang, 1977). Methyl-Hg intoxicated harp seals showed a low level of damage of sensory cells of the organ of Corti (Ramprashad & Ronald, 1977).

Some researchers have used an indirect approach to investigate the prediction that metal pollutants result in lower resistance to diseases. The endangered population of belugas (*Delphinapterus leucas*) in the polluted estuary of the St. Lawrence River showed high concentrations of organochlorines, heavy metals, and benzo[*a*]pyrene in tissues as well as a high prevalence of tumors which suggests an influence of contaminants through a direct carcinogenic effect and/or a decreased resistance to the development of tumors (De Guise, Lagace, & Beland, 1994). Siebert et al. (1999) investigated Hg body burden and diseases in harbor porpoises (*Phocoena phocoena*) from the German Waters of the North and Baltic Seas. High Hg concentrations were associated with a prevalence of parasitic infections and pneumonia. Bennett et al. (2001) investigated harbor porpoises found dead along the coasts of

England and Wales that died as a consequence of physical trauma as well as infectious diseases. They found that the mean liver concentrations of Hg, Se, the Hg:Se molar ratio and Zn were significantly higher in the porpoises that died of infectious diseases in comparison to those who died because of a physical trauma. Similarly, Kannan, Agusa, Perrotta, Thomas, & Tanabe (2006) and Kannan, Guruge, Thomas, Tanabe, & Giesy (1998) investigated the concentrations of butyl-Sn residues and trace elements in sea otters (*Enhydra lutris nereis*) found dead along the California coastal waters. They studied otters that died due to infectious diseases as well as those that died because of other reasons. Otters that died because of infectious diseases indicated higher concentrations of butyl-Sn in comparison to those that died as a result of physical trauma. The concentrations of Mn, Co, Zn, and Cd were elevated in the diseased and emaciated sea otters relative to the non-diseased sea otters. An elevated accumulation of tributyl-Sn was also found in bottlenose dolphins (*Tursiops truncatus*) stranded along the Atlantic and Gulf coasts of Florida (Kannan et al., 1997). These relationships are substantiated by the fact that the pollution with metals may affect the immunocompetence and disrupt the immune homeostasis of free-ranging populations of marine mammals in many areas of the industrialized world.

Metal influences on immune functions

Metals influence the function of immunocompetent cells by a variety of mechanisms. Depending on the particular metal, its speciation, concentration and bioavailability, and a number of other factors, a continuous metal exposure will result in an immunoenhancement or immunosuppression effects. Reviews of immunomodulation by metals in humans or laboratory animals include those of Chang (1996), Dean, Luster, Munson & Kimber (1994), or Lawrence & McCabe (2002), but metal influences on marine mammals in relation to environmental contamination have been only poorly investigated.

Immune cells such as macrophages can incorporate and store metal components, e.g. Hg and Se in mineral granules, as described for various marine mammal species (Nigro & Leonzio, 1996). In *in vitro* experiments, a similar incorporation of Ti was shown for blood macrophages of harbor seals (Figure 1a). Depending on the concentration, metals can be cytotoxic for immune cells as well as inhibit or stimulate cell functions, the latter in all probability by binding to proteins.

Killer cell activity, phagocytosis and transformation of lymphocytes have been investigated in various marine mammal species and evidence for the immunosuppression function of metal pollutants has been provided. The mitogen-induced proliferation of immune cells was inhibited by butyl-Sn compounds in several marine mammals and humans (Nakata et al., 2002). Phagocytosis and lymphoblast transformation in grey seal pups were adversely affected by Hg *in vitro* (Lalancette, Morin, Measures, & Fournier, 2003). The effects of heavy metals on beluga whale splenocytes and thymocytes *in vitro* indicate functional impairment (De Guise, Bernier, Martineau, Beland, & Fournier, 1996). Pillet et al. (2000) found a sex-dependent effect of Zn on phagocytic activity. In a study on harbor seal pups from the North Sea, lymphocyte proliferation was especially inhibited by Be, Pb, Cd and Hg in newborn pups (Kakuschke et al., 2008c). Interestingly, the susceptibility to the toxic effects of metals seems to be decreased in infant pups.

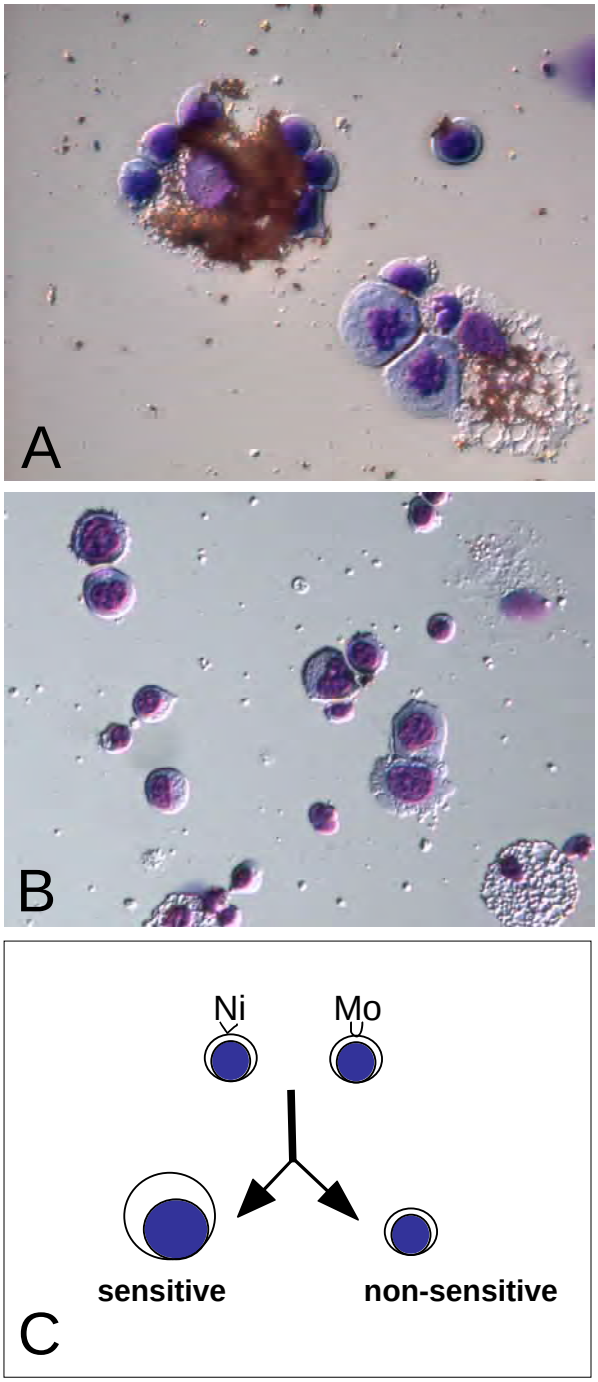


Figure 1. Morphological analysis of Ti-induced (A) and Ni-induced (B) lymphocyte proliferation. In A: two lymphoblasts, one macrophage with ingested titanium particle, and several resting lymphocytes. In B: several lymphoblasts, one macrophage, and resting lymphocytes. C: Principal transformation of lymphocytes.

In addition to immunosuppression, metal pollutants may induce immunoenhancement leading to hypersensitivity and autoimmunity. Even though the metal input into the marine system appears to have been decreasing

in recent years, low-level metal concentrations can modulate the immune system. The chronic intake of metal pollutants renders marine mammals candidates for developing hypersensitivity reactions. A lymphocyte transformation test for detecting antigen-specific metal sensitivities according to the MELISA® (memory lymphocyte immuno-stimulation assay) (Stejskal, Cederbrant, Lindvall, & Forsbeck, 1994; Valentine-Thon & Schiwara, 2003; Valentine-Thon, Sandkamp, Müller, Guzzi, & Hartmann, 2005) was used to investigate pinnipeds from the North Sea (Kakuschke et al., 2005, 2006). The method is based on the fact that lymphocytes, which have been sensitized by a certain metal ("memory cells"), transform into blasts and proliferate when they are re-exposed to this metal (Figure 1). Altogether 31 pinnipeds from the North Sea were investigated, including 13 pups and 17 adult harbor seals as well as one grey seal (Kakuschke, 2006). 13 of these 31 animals showed such a metal-specific delayed type hypersensitivity reaction. The frequency of sensitizing metals was in the order Mo > Ni > Ti > Cr, Al > Pb, Be, Sn. Furthermore, a relationship between the blood levels of metals and this immunological dysfunction was reported (Kakuschke et al., 2005).

In the case study of the grey seal the hypersensitivity reaction to Ni and Be could be validated by different approaches – the proliferation of memory lymphocytes as well as the altered cytokine pattern (Kakuschke et al., 2006). With the cytokines interleukin-2 (IL-2) and interleukin-4 (IL-4) it is possible to distinguish between T-helper 1 (Th1), IL-2 secreting cells and T-helper 2 (Th2), IL-4 producing cells (Elenkov & Chrousos, 1999). The impact of stress on the cytokine pattern was recently described for harbor porpoises from the North Sea (Fonfara, Siebert, Prange, & Colijn, 2007). Kakuschke et al. (2006) measured the mRNA-expression of IL-2 and IL-4 in grey seal lymphocytes co-cultivated with the sensitizing metals Ni and Be as well as the non-sensitizing metals Hg and Cd. Ni and Be induced the lowest cytokine expression compared to the other metals and the quotient IL2/IL4 was increased due to a strong down-regulation of the Th2 cytokine IL-4, which suggests an antigen-specific delayed-type hypersensitivity reaction with a Th1/Th2 polarization toward Th1 (Kidd 2003).

Summary

The environmental exposure with metals is believed to affect marine mammal health adversely. One mechanism whereby metals can alter the health status is through modulation of immune homeostasis. Metals may change the response repertoire by direct and indirect means, which include changes in cell proliferation, phagocytosis, protein expression or other cell functions. Some resulting effects may include immunosuppression or acute as well as chronic inflammatory processes leading to hypersensitivities or autoimmune diseases. The multiple influences of metals on the immune system underline the importance of metals pollution as a potential stressor for marine mammals.

References

Achterberg, E.P., van den Berg C.M.G., & Colombo, C. (2003). High resolution monitoring of dissolved Cu and Co in coastal surface waters of the Western North Sea. *Continental Shelf Research*, **23**, 611-623.

Andersen, S.H., & Rebsdorff, A. (1976). Polychlorinated hydrocarbons and heavy metals in harbour porpoise (*Phocoena phocoena*) and whitebeaked dolphin (*Lagenorhynchus albirodtris*) from danish waters. *Aquatic mammals*, **4**, 14-20.

Bakker, J. F., van den Heuvel-Greve, M., & Vethaak, D. (2005). Natural contaminants. In K. Essink, C. Dettmann, H. Farke, K. Laursen, G. Lüerßen, H. Marencic, W. Wiersinga (Eds.), *Wadden Sea Quality Status Report 2004. Wadden Sea Ecosystem No. 19*.

Baraj, B., Bianchini, A., Niencheski, L. F. H., Campos, C. C. R., Martinez, P. E., Robaldo, R. B., Muelbert, M. M. C., Colares, E. P., & Zarzur, S. (2001). The performance of ZEISS GFAAS-5 instrument on the determination of trace metals in whole blood samples of southern elephant seals (*Mirounga leonina*) from Antarctica. *Fresenius Environmental Bulletin*, **10**, 859-862.

Bennett, P. M., Jepson, P. D., Law, R. J., Jones, B. R., Kuiken, T., Baker, J. R., Rogan, E., & Kirkwood, J. K. (2001). Exposure to heavy metals and infectious disease mortality in harbour porpoises from England and Wales. *Environmental Pollution*, **112**, 33-40.

Berge, J.A., Brevik, E.M., Bjorge, A, Folsvik, N., Gabrielsen, G.W., & Wolkers, H. (2004). Organotins in marine mammals and seabirds from Norwegian territory. Journal of Environmental Monitoring, **6**, 108-112.

Breuer, E., Stevenson, A.G., Howe, J.A., Carroll, J., & Shimmield, G.B. (2004). Drill cutting accumulations in the Northern and Central North Sea: A review of environmental interactions and chemical fate. *Marine Pollution Bulletin*, **48**,12-25.

Broeg, K., Zander, S., Diamant, A., Korting, W., Kruner, G., Paperna, I., & von Westernhagen, H. (1999). The use of fish metabolic, pathological and parasitological indices in pollution monitoring - 1. North Sea. *Helgoland Marine Research*, **53**, 171-194.

Bruhn, R., Kannan, N., Petrick, G., Schulz-Bull, D. E., & Duinker, J. C. (1999). Persistent chlorinated organic contaminants in harbor porpoises from the North Sea, the Baltic Sea and Arctic waters. *Science of the Total Environment*, **238**, 351-361.

Caurant, F., & Amiard-Triquet, C. (1995). Cadmium contamination in pilot whales *Globicephala melas* - source and potential hazard to the species. *Marine Pollution Bulletin*, **30**, 207-210.

Chang, L. W. (1996). *Toxicology of metals*. Boca Raton, New York, London, Tokyo: CRC Lewis Publishers.

Chapman, P.M. (1992). Pollution status of North Sea sediments - an international integrative study. *Marine Ecology-Progress Series*, **91**, 313-322.

Ciesielski T. , Szefer P., Bertenyi Z., Kuklik I., Skora K,. Namiesnik J., & Fodor P. (2006). Interspecific distribution and co-associations of chemical elements in the liver tissue of marine mammals from the Polish Economical Exclusive Zone, Baltic Sea. *Environment International*, **32**, 524-532.

Ciesielski, T., Wasik, A., Kuklik, I., Skora, K., Namiesnik, J., & Szefer, P. (2004). Organotin compounds in the liver tissue of marine mammals from the polish coast of the Baltic Sea. *Environmental Science & Technology*, **38**, 1415-1420.

Croot, P.L., Karlson, B., Wulff, A., Linares, F., & Andersson, K. (2002). Trace metal/phytoplankton interactions in the Skagerrak. *Journal of Marine Systems*, **35**, 39-60.

Danis, B., Wantier, P., Flammang, R., Pernet, P., Chambost-Manciet, Y., Coteur, G., Warnau, M., & Dubois, P., (2006). Bioaccumulation and effects of PCBs and heavy metals in sea stars (*Asterias rubens*, L.) from the North Sea: A small scale perspective. *Science of the Total Environment*, **356**, 275-289.

Danis, B., Wantier, P., Dutrieux, S., Flammang, R., Dubois, P., & Warnau, M. (2004). Contaminant levels in sediments and asteroids (*Asterias rubens* L., Echinodermata) from the Belgian coast and Scheldt estuary: polychlorinated biphenyls and heavy metals. Science of the Total Environment, **333**, 149-165.

Das, K., Debacker, V., Pillet, S., & Bouquegneau, J. M. (2003). Heavy metals in marine mammals, *Toxicology of Marine Mammals* (pp. 135-167). London: Taylor & Francis Ltd.

Das, K., Siebert, U., Fontaine, M., Jauniaux, T., Holsbeek, L., & Bouquegneau, J. M. (2004). Ecological and pathological factors related to trace metal concentrations in harbor porpoises *Phocoena phocoena* from the North Sea and adjacent areas. *Marine Ecology-Progress Series*, **281**, 283-295.

Dean, J. H., Luster, M. I., Munson, A. E., & Kimber, I. (1994). *Immunotoxicology and immunopharmacology* (2nd ed.). New York: Raven Press.

Debacker, V., Jauniaux, T., Coignoul, F., & Bouquegneau, J.M. (2000). Heavy metals contamination and body condition of wintering guillemots (*Uria aalge*) at the Belgian coast from 1993 to 1998. *Environmental Research*, **84**, 310-317.

De Guise, S., Bernier, J., Martineau, D., Beland, P., & Fournier, M. (1996). Effects of in vitro exposure of beluga whale splenocytes and thymocytes to heavy metals. *Environmental Toxicology and Chemistry*, **15**, 1357-1364.

De Guise, S., Lagace, A., & Beland, P. (1994). Tumors in St-Lawrence beluga whales (*Delphinapterus leucas*). *Veterinary Pathology*, **31**, 444-449.

Dippner, J.W., & Pohl, C. (2004). Trends in heavy metal concentrations in the Western and Central Baltic Sea waters detected by using empirical orthogonal functions analysis. *Journal of Marine Systems*, **46**, 69-83.

Drescher, H.E., Harms, U., & Huschenbeth, E. (1977). Organochlorines and heavy metals in harbor seal *Phoca vitulina* from German North Sea coast. *Marine Biology*, **41**, 99-106.

Duinker, J.C., Hillebrand, M.T.J., & Nolting, R.F. (1979). Organochlorines and metals in harbor seals (Dutch Wadden Sea). *Marine Pollution Bulletin*, **10**, 360-364.

Elenkov, I. J., & Chrousos, G. P. (1999). Stress hormones, Th1/Th2 patterns, pro/anti-inflammatory cytokines and susceptibility to disease. *Trends in Endocrinology and Metabolism*, **10**, 359-368.

Falconer, C.R., Davies, I.M., & Topping, G. (1983a). Trace metals in the common porpoise, *Phocoena phocoena*. *Marine Environmental Research*, **8**, 119-127.

Falconer, C.R., Shepherd, R.J., Pirie, J.M., & Topping, G. (1983b). Arsenic levels in fish and shellfish from the North Sea. *Journal of Experimental Marine Biology and Ecology*, **71**, 193-203.

Fant, M. L., Nyman, M., Helle, E., & Rudbäck, E. (2001). Mercury, cadmium, lead and selenium in ringed seals (*Phoca hirspida*) from the Baltic Sea and from Svalbard. *Environmental Pollution*, **111**, 493-501.

Fonfara, S., Siebert, U., Prange, A., & Colijn, F. (2007). The impact of stress on cytokine and haptoglobin mRNA expression in blood samples from harbor porpoises (*Phocoena phocoena*). *Journal of the Marine Biological Association of the UK*, **87**, 305-311.

Frank, A., Galgan, V., Roos, A., Olsson, M., Petersson, L. R., & Bignert, A. (1992). Metal concentrations in seals from Swedish waters. *Ambio*, **21**, 529-538.

Freeman, H. C., & Sangalang, G. B. (1977). Study of effects of methyl mercury, cadmium, arsenic, selenium, and a PCB, (Aroclor 1254) on adrenal and testicular steroidogenesis *in-vitro*, by gray seal *Halichoerus grypus*. *Archives of Environmental Contamination and Toxicology*, **5**, 369-383.

Freeman, H. C., Sangalang, G., Uthe, J. F., & Ronald, K. (1975). Steroidogenesis *in-vitro* in harp seal (*Pagophilus groenlandicus*) without and with methyl mercury treatment *in-vivo*. *Environmental Physiology & Biochemistry*, **5**, 428-439.

Griesel, S., Kakuschke, A., Siebert, U., & Prange, A. (2008). Trace element concentrations in blood of harbor seals (*Phoca vitulina*) from the Wadden Sea. *Science of the Total Environment*, **392**, 313-323.

Griesel, S., Mundry, R., Kakuschke, A., Fonfara, S., Siebert, U., & Prange, A. (2006). Mineral elements and essential trace elements in blood of seals of the North Sea measured by total-reflection X-ray fluorescence analysis. *Spectrochimica Acta Part B*, **61**, 1158-1165.

Guns, M., Vanhoeyweghen, P., Vyncke, W., & Declerck, R. (1992). Selenium assessment and its relation to mercury levels in fish, shrimp and mussels from Belgian Continental Shelf Waters. *Landbouwtijdschrift-Revue De L Agriculture*, **45**, 731-739

Hall, A. J., Duck, C. D., Law, R. J., Allchin, C. R., Wilson, S., & Eybator, T. (1999). Organochlorine contaminants in Caspian and harbor seal blubber. *Environmental Pollution*, **106**, 203-212.

Harms, U., Drescher, H.E., & Huschenbeth, E. (1978). Further data on heavy metals and organochlorines in marine mammals from German Coastal Waters. *Meeresforschung - Reports on Marine Research*, **26**, 153-161.

Henry, F., Amara, R., Courcot, L., Lacouture, D., & Bertho, M.L. (2004). Heavy metals in four fish species from the French coast of the eastern English Channel and Southern Bight of the North Sea. *Environment International*, **30**, 675-683.

Hinrichs, J., Dellwig, O., & Brumsack, H.J. (2002). Lead in sediments and suspended particulate matter of the German Bight: natural versus anthropogenic origin. *Applied Geochemistry*, **17**, 621-632.

Holsbeek, L., Joiris, C. R., Debacker, V., Ali, I. B., Roose, P., Nellissen, J. P., Gobert, S., Bouquegneau, J. M., & Bossicart, M. (1999). Heavy metals, organochlorines and polycyclic aromatic hydrocarbons in sperm whales stranded in the southern North Sea during the 1994/1995 winter. *Marine Pollution Bulletin*, **38**, 304-313.

Hyvärinen, H., & Sipilä, T. (1984). Heavy metals and high pup mortality in the Saimaa ringed seal population in Eastern Finland. *Marine Pollution Bulletin*, **15**, 335-337.

Joiris, C.R., Holsbeek, L., Bouquegneau, J.M., & Bossicart, M. (1991). Mercury contamination of the harbor porpoise *Phocoena phocoena* and other cetaceans from the North Sea and the Kattegat. *Water Air and Soil Pollution*, **56**, 283-293.

Jung, K, Stelzenmuller, V., & Zauke, G.P. (2006). Spatial distribution of heavy metal concentrations and biomass indices in *Cerastoderma edule* Linnaeus (1758) from the German Wadden Sea: An integrated biomonitoring approach. *Journal of Experimental Marine Biology and Ecology*, **338**, 81-95.

Kakuschke, A. (2006). *Einfluss von Metallen auf das Immunsytem von Meeressäugern.* Dissertationsschrift, Universität Hamburg, Hamburg, Deutschland.

Kakuschke, A., Griesel, S., & Prange, A. (2008a). Variations of metal concentration in blood of harbour seal (*Phoca vitulina*) pups of the German North Sea. *Biological Trace Element Research*, in press.

Kakuschke, A., Valentine-Thon, E., Fonfara, S., Griesel, S., Siebert, U., & Prange, A. (2006). Metal sensitivity of marine mammals: A case study of a gray seal (*Halichoerus grypus*). *Marine Mammal Science*, **22**, 985-996.

Kakuschke, A., Valentine-Thon, E., Fonfara, S., Griesel, S., Rosenberger, T., Siebert, U., & Prange, A. (2008c). Metal-induced impairment of the cellular immunity of newborn harbour seals (*Phoca vitulina*). *Archives of Environmental Contamination and Toxicology*, DOI: 10.1007/s00244-007-9092-3.

Kakuschke, A., Valentine-Thon, E., Griesel, S., Fonfara, S., Siebert, U., & Prange, A. (2005). Immunological impact of metals in harbor seals (*Phoca vitulina*) of the North Sea. *Environmental Science & Technology*, **39**, 7568-7575.

Kakuschke, A., Valentine-Thon, E., Griesel, S., Rosenberger, T., Mundry, R., Siebert, U., & Prange, A. (2008b). Blood metal levels and metal-influenced immune functions of harbour seals in captivity. *Marine Pollution Bulletin*, **56**, 764-769.

Kalantzi, O. I., Hall, A. J., Thomas, G. O., & Jones, K. C. (2005). Polybrominated diphenyl ethers and selected organochlorine chemicals in grey seals (*Halichoerus grypus*) in the North Sea. *Chemosphere*, **58**, 345-354.

Kannan, K., Agusa, T., Perrotta, E., Thomas, N. J., & Tanabe, S. (2006). Comparison of trace element concentrations in livers of diseased, emaciated and non-diseased southern sea otters from the California coast. *Chemosphere*, **65**, 2160-2167.

Kannan, K., Corsolini, S., Falandysz, J., Oehme, G., Focardi, S., & Giesy, J. P. (2002). Perfluorooctanesulfonate and related fluorinated hydrocarbons in marine mammals, fishes, and birds from coasts of the Baltic and the Mediterranean Seas. *Environmental Science & Technology*, **36**, 3210-3216.

Kannan, K., & Falandysz, J. (1997). Butyltin residues in sediment, fish, fish-eating birds, harbour porpoise and human tissues from the Polish coast of the Baltic Sea. *Marine Pollution Bulletin*, **34**, 203-207.

Kannan, K., Guruge, K.S., Thomas, N.J., Tanabe, S., & Giesy, J.P. (1998). Butyltin residues in southern sea otters (*Enhydra lutris nereis*) found dead along California coastal waters. *Environmental Science & Technology*, **32**, 1169-1175.

Kannan, K., Senthilkumar, K., Loganathan, B.G., Takahashi, S., Odell, D.K., & Tanabe, S. (1997). Elevated accumulation of tributyltin and its breakdown products in bottlenose dolphins (*Tursiops truncatus*) found stranded along the US Atlantic and Gulf coasts. *Environmental Science & Technology*, **31**, 296-301.

Kersten, M. D., M.; Kriews, M.; Naumann, K.; Schmidt, D.; Schulz, M.; Schwikowski, M.; & Steiger, M. (1988). Distribution and fate of heavy metals in the North Sea. In W. B. Salomons, B.L.; Duursma, E.K.; & Förster, U. (Eds.), *Pollution of the North Sea. An Assessment.* Berlin, Heidelberg: Springer Verlag.

Kidd, P. (2003). Th1/Th2 balance: the hypothesis, its limitations, and implications for health and disease. *Alternative Medicine Review*, **8**, 223-246.

Kleivane, L., Skaare, J. U., Bjorge, A., Deruiter, E., & Reijnders, P. J. H. (1995). Organochlorine pesticide-residue and PCBs in harbor porpoise (*Phocoena phocoena*) incidentally caught in Scandinavian Waters. *Environmental Pollution*, **89**, 137-146.

Kremling, K., & Hydes, D. (1988). Summer distribution of dissolved Al, Cd, Co, Cu, Mn and Ni in surface waters around the British Isles. *Continental Shelf Research*, **8**, 89-105.

Laane, R., Sonneveldt, H.L.A., Van der Weyden, A.J., Loch, J.P.G., & Groeneveld, G. (1999). Trends in the spatial and temporal distribution of metals (Cd, Cu, Zn and Pb) and organic compounds (PCBs and PAHs) in Dutch coastal zone sediments from 1981 to 1996: A model case study for Cd and PCBs. *Journal of Sea Research*, **41**, 1-17.

Lahaye, V., Bustamante, P., Law, R.J., Learmonth, J.A., Santos, M.B., Boon, J.P., Rogan, E., Dabin, W., Addink, M.J., Lopez, A., Zuur, A.F., Pierce, G.J., & Caurant, F. (2007). Biological and ecological factors related to trace element levels in harbour porpoises (*Phocoena phocoena*) from European waters. *Marine Environmental Research*, **64**, 247-266.

Lalancette, A., Morin, Y., Measures, L., & Fournier, M. (2003). Contrasting changes of sensitivity by lymphocytes and neutrophils to mercury in developing grey seals. *Developmental and Comparative Immunology*, **27**, 735-747.

Law, R. J., Allchin, C. R., Bennett, M. E., Morris, S., & Rogan, E. (2002). Polybrominated diphenyl ethers in two species of marine top predators from England and Wales. *Chemosphere*, **46**, 673-681.

Law, R. J., Bennett, M. E., Blake, S. J., Allchin, C. R., Jones, B. R., & Spurrier, C. J. H. (2001). Metals and organochlorines in pelagic cetaceans stranded on the coasts of England and Wales. *Marine Pollution Bulletin*, **42**, 522-526.

Law, R. J., Blake, S. J., Jones, B. R., & Rogan, E. (1998). Organotin compounds in liver tissue of harbour porpoises (*Phocoena phocoena*) and grey seals (*Halichoerus grypus*) from the coastal waters of England and Wales. *Marine Pollution Bulletin*, **36**, 241-247.

Law, R. J., Blake, S. J., & Spurrier, C. J. H. (1999). Butyltin compounds in liver tissues of pelagic cetaceans stranded on the coasts of England and Wales. *Marine Pollution Bulletin*, **38**, 1258-1261.

Law, R. J., Fileman, C. F., Hopkins, A. D., Baker, J. R., Harwood, J., Jackson, D. B., Kennedy, S., Martin, A. R., & Morris, R. J. (1991). Concentrations of trace-metals in the livers of marine mammals (seals, porpoises and dolphins) from waters around the British Isles. *Marine Pollution Bulletin*, **22**, 183-191.

Law, R. J., Jones, B. R., Baker, J. R., Kennedy, S., Milne, R., & Morris, R. J. (1992). Trace metals in the livers of marine mammals from the Welsh Coast and the Irish Sea. *Marine Pollution Bulletin*, **24**, 296-304.

Lawrence, D. A., & McCabe, M. J. (2002). Immunomodulation by metals. *International Immunopharmacology*, **2**, 293-302.

Millward, G.E., Morris, A.W., & Tappin, A.D. (1998). Trace metals at two sites in the southern North Sea: Results from a sediment resuspension study. *Continental Shelf Research*, **18**, 1381-1400.

Morris, R.J., Law, R.J., Allchin, C.R., Kelly, C.A., & Fileman, C.F. (1989). Metals and Organochlorines in Dolphins and Porpoises of Cardigan Bay, West Wales. *Marine Pollution Bulletin*, **20**, 512-523.

Nakata, H., Sakakibara, A., Kanoh, M., Kudo, S., Watanabe, H., Nagai, N., Miyazaki, N., Asano, Y., & Tanabe, S. (2002). Evaluation of mitogen-induced responses in marine mammal and human lymphocytes by *in-vitro* exposure of butyltins and non-ortho coplanar PCBs. *Environmental Pollution*, **120**, 245-253.

Nielsen, J. B., Nielsen, F., Jorgensen, P. J., & Grandjean, P. (2000). Toxic metals and selenium in blood from pilot whales (*Globicephala melas*) and sperm whales (*Physeter catodon*). *Marine Pollution Bulletin*, **40**, 348-351.

Nigro, M., & Leonzio, C. (1996). Intracellular storage of mercury and selenium in different marine vertebrates. *Marine Ecology-Progress Series*, **135**, 137-143.

O'Shea, T. J. (1999). Environmental contaminants and marine mammals. In J. E. Reynolds & S. A. Rommel (Eds.), *Biology of marine mammals*. Washington, London: Smithsonian Institution Press.

Perttilä, M., Tervo, V., & Parmanne, R. (1982a). Age dependence of the concentrations of harmful substances in baltic herring (*Clupea harengus*). Chemosphere, **11**, 1019-1026.

Perttilä, M., Tervo, V., & Parmanne, R. (1982b). Heavy metals in Baltic herring and cod. *Marine Pollution Bulletin*, **13**, 391-393.

Pillet, S., Lesage, V., Hammill, M., Cyr, D. G., Bouquegneau, J. M., & Fournier, M. (2000). *In vitro* exposure of seal peripheral blood leukocytes to different metals reveal a sex-dependent effect of zinc on phagocytic activity. *Marine Pollution Bulletin*, **40**, 921-927.

Rachor, E., & Rühl, N.-P. (1990). Schadstoffeinträge. In J. L. Lozan, W. Lenz, E. Rachor, B. Watermann, & H. von Westernhagen (Eds.), *Warnsignale aus der Nordsee*. Berlin, Hamburg: Verlag Paul Parey.

Ramprashad, F., & Ronald, K. (1977). Surface preparation study on effect of methyl mercury on sensory hair cell-population in cochlea of harp seal (*Pagophilus groenlandicus* Erxleben, 1777). *Canadian Journal of Zoology-Revue Canadienne De Zoologie*, **55**, 223-230.

Rawson, A. J., Patton, G. W., Hofmann, S., Pietra, G. G., & Johns, L. (1993). Liver abnormalities associated with chronic mercury accumulation in stranded Atlantic bottle nosed dolphins. *Ecotoxicology and Environmental Safety*, **25**, 41-47.

Reijnders, P. J. H. (1980). Organochlorine and heavy metal residues in harbor seals from the Wadden Sea and their possible effects on reproduction. *Netherlands Journal of Sea Research*, **14**, 30-65.

Reijnders, P. J. H., Aguilar, A., & Donovan, G. P. (1999). Chemical pollutants and cetaceans. *Journal of Cetacean Research and Management, Special Issue 1*.

Ronald, K., Tessaro, S. V., Uthe, J. F., Freeman, H. C., & Frank, R. (1977). Methyl mercury poisoning in the harp seal (*Pagophilus groenlandicus*). *The Science of the Total Environment*, **8**, 1-11.

Schmolke, S. R., Haarich, M., Petenati, T., Obert, B., Schubert, B., Becker, P., Harms, U., Schröter-Kermani, C., & Steffen, D. (2005). Anorganische Schadstoffe, *Bund - Länder - Messprogramm: Meeresumwelt 1999 - 2002 Nordsee*. Hamburg, Rostock: Bundesamt für Schifffahrt und Hydrographie (BSH).

Shlosberg, A., Bellaiche, M., Regev, S., Gal, R., Brizzi, M., Hanji, V., Zaidel, L., & Nyska, A. (1997). Lead toxicosis in a captive bottlenose dolphin (*Tursiops truncatus*) consequent to ingestion of air gun pellets. *Journal of Wildlife Diseases*, **33**, 135-139.

Skaare, J.U., Markussen, N.H., Norheim, G., Haugen, S., & Holt, G. (1990). Levels of polychlorinated biphenyls, organochlorine pesticides, mercury, cadmium, copper,

selenium, arsenic, and zinc in the harbor seal, *Phoca vitulina*, in Norwegian Waters. Environmental Pollution, **66**, 309-324.

Skwarzec, B., Holm, E., Roos, P., & Pempkowiak, J. (1994). Ni-63 in Baltic fish and sediments. *Applied Radiation and Isotopes*, **45**, 609-611.

Siebert, U., Joiris, C., Holsbeek, L., Benke, H., Failing, K., Frese, K., & Petzinger, E. (1999). Potential relation between mercury concentrations and necropsy findings in cetaceans from German waters of the North and Baltic Seas. *Marine Pollution Bulletin*, **38**, 285-295.

Sormo, E. G., Skaare, J. U., Jussi, I., Jussi, M., & Jenssen, B. M. (2003). Polychlorinated biphenyls and organochlorine pesticides in Baltic and Atlantic gray seal (*Halichoerus grypus*) pups. *Environmental Toxicology and Chemistry*, **22**, 2789-2799.

Stejskal, V. D. M., Cederbrant, K., Lindvall, A., & Forsbeck, M. (1994). Melisa - an *in-vitro* tool for the study of metal allergy. *Toxicology in Vitro*, **8**, 991-1000.

Szefer, P., Szefer, K., Glasby, G.P., Pempkowiak, J., & Kaliszan, R. (1996). Heavy metal pollution in surficial sediments from the Southern Baltic Sea off Poland. *Journal of Environmental Science and Health - Part A*, **31**, 2723-2754.

Szefer, P., Zdrojewska, I., Jensen, J., Lockyer, C., Skora, K., Kuklik, I., & Malinga, M. (2002). Intercomparison studies on distribution and co-associations of heavy metals in liver, kidney, and muscle of harbor porpoise, *Phocoena phocoena*, from southern Baltic Sea and coastal waters of Denmark and Greenland. *Archives of Environmental Contamination and Toxicology*, **42**, 508-522.

Troisi, G. M., Haraguchi, K., Kaydoo, D. S., Nyman, M., Aguilar, A., Borrell, A., Siebert, U., & Mason, C. F. (2000). Bioaccumulation of polychlorinated biphenyls (PCBs) and dichlorodiphenylethane (DDE) methyl sulfones in tissues of seal and dolphin morbillivirus epizootic victims. *Journal of Toxicology and Environmental Health-Part A*, **62**, 1-8.

Valentine-Thon, E., Sandkamp, M., Müller, K., Guzzi, G., & Hartmann, T. (2005). Metallsensibilisierung: Nachweis, Validierung und Verlaufskontrolle mittels Lymphocyten-Transformations-Test (LTT-MELISA). *Zeitschrift für Orthomolekulare Medizin*, **1**, 12-15.

Valentine-Thon, E., & Schiwara, H. W. (2003). Validity of MELISA for metal sensitivity testing. *Neuroendocrinology Letters*, **24**, 57-64.

Van de Vijver, K. I., Hoff, P. T., Das, K., Van Dongen, W., Esmans, E. L., Siebert, U., Bouquegneau, J. M., Blust, R., & De Coen, W. M. (2004). Baseline study of perfluorochemicals in harbor porpoises (*Phocoena phocoena*) from Northern Europe. *Marine Pollution Bulletin*, **48**, 992-997.

Wängberg, I., Munthe, J., Berg, T., Ebinghaus, R., Kock, H. H., Temme, C., Bieber, E., Spain, T. G., & Stolk, A. (2007). Trends in air concentration and deposition of mercury in the coastal environment of the North Sea Area. *Atmospheric Environment*, **41**, 2612-2619.

Wenzel, C., Adelung, D., Kruse, H., & Wassermann, O. (1993). Trace metal accumulation in hair and skin of the harbor seal, *Phoca vitulina*. *Marine Pollution Bulletin*, **26**, 152-155.

Wenzel, C., Adelung, D., & Theede, H. (1996). Distribution and age-related changes of trace elements in kittiwake Rissa tridactyla nestlings from an isolated colony in the German Bight, North Sea. *Science of the Total Environment*, **193**, 13-26.

International Journal of Comparative Psychology, 2007, **20**, 194-216.
Copyright 2007 by the International Society for Comparative Psychology

Potential Synergism between Stress and Contaminants in Free-ranging Cetaceans

Daniel Martineau
University of Montreal, Canada

Noise has increased significantly over the last decades in oceans, and this trend is accelerating in large part because of oil exploration and exploitation, both of which are expanding worldwide. Considered together with recent evidence that noise disturbs the behavior, echolocation, navigation and communication of marine mammals, it is likely that noise, increasingly encountered by marine mammals, will add to their allostatic load. Glucocorticoids (GCs) are the major hormones that mediate the long term effects of stress. GCs' effects depend, among other factors, on the intracellular concentrations of the various isoforms of the glucocorticoid receptors (GR). Tissue and cell-type specificity are also conferred by the presence in target cells of GR ligands such as chaperones, co-chaperones and modulatory element binding proteins whose concentrations vary according to tissue, cell types and even to the cell cycle phase. The normal regulation of GCs production in adult life relies on the normal development of the hypothalamus-pituitary adrenal (HPA) axis in uterine and early postnatal life, which in turn depends on the absence of chronic stress imposed to both the mother and newborn during these critical periods. Worldwide, cetacean populations, such as the beluga population inhabiting the St Lawrence Estuary (SLE) in Canada, are exposed to anthropogenic stressors, and are contaminated by persistent lipophilic contaminants of which many are abundantly transferred to newborns during lactation. GCs and certain organochlorine contaminants (OCs), for instance dioxin-related polychlorinated biphenyls (DRPBs), mediate their prolonged and profound effects through nuclear receptors such as aryl hydrocarbon receptors (AhR). These effects are exerted on most organs, especially on the developing brain and lymphoid organs of fetuses and juveniles and on adrenal glands of adult mammals. Multiple interactions have been demonstrated between GCs and OCs, often through interactions between their receptors. These interactions may disturb the delicate balance required by immature and adult mammals to react optimally to stressors.

Stressors elicit a fairly stereotyped response in higher vertebrates, including marine mammals. In general, the elevation of circulating GCs levels that follows exposure to various stressors – including noise - is beneficial. High GC levels become detrimental however when they occur over a long period, when the stressor is persistent or repeated (Deak, this issue; Romero & Butler, this issue; Sapolsky, Romero, & Munck, 2000; St. Aubin, De Guise, Richard, Smith, & Geraci, 2001; St Aubin & Dierauf, 2001).

The sympathetic nervous system (SNS) responds within seconds to stressors by releasing preformed catecholamines (CAs) (epinephrine and norepinephrine) from the adrenal medulla into the blood circulation. This release quickly increases heart rate and blood pressure, which is part of the acute - or fight or flight – response. These effects occur within seconds because CAs bind adrenergic receptors present in peripheral tissues. The binding triggers an

This work was supported by a grant from the Natural Sciences and Engineering Research Council of Canada (no. 138236) to DM and by a grant from Fisheries and Oceans Canada. We thank Stephane Lair for constructive discussions and M. Naud for technical expertise. Correspondence concerning this article should be addressed to Daniel Martineau, Département de Pathologie et Microbiologie, Faculté de Médecine, Vétérinaire Université de Montréal, 3200 Sicotte, Saint-Hyacinthe, QC, J2S 7C5, Canada. (Daniel.martineau@umontreal.ca)

immediate intracellular biochemical cascade through secondary messengers (Romero & Butler, this issue). When extreme, this response may kill animals and humans through CAs' toxic effects on heart muscle fibers (McEwen, 1998, 2000). In addition, within several minutes, CAs induce the production of T helper cells (Th)-1, proinflammatory (or cell-mediated immunity) cytokines (see below), probably to prepare the organism to fight bacterial invasions secondary to potential wounds.

Concurrently with CA release, hypothalamic neurons trigger indirectly the release of GCs from the adrenal glands. Hypothalamic neurons first signal the pituitary to release ACTH via the corticotrophin releasing hormone (CRH). In turn and within minutes, ACTH triggers the synthesis and release of GCs from the adrenal cortex where GCs are synthesized from cholesterol (hence their lipophilicity). GCs are then distributed indiscriminately throughout the stressed organism, and traverse the lipid-based cytoplasmic membranes of most cells. This broad distribution explains in part GCs' impact on a wide variety of cells. Each cell type, including inner ear cells (cochlea, organ of Corti), is distinguished by the presence of various isoforms of intracytoplasmic GR and other GC ligands such as chaperones, co-chaperones, and modulatory element binding proteins (heat shock protein 90 (hsp 90), immunophilins and GMEB-1 respectively), ensuring that GCs' effects are tissue and cell type specific (Canlon, Meltser, Johansson, & Tahera, 2007; De Bosscher, Vanden Berghe, & Haegeman, 2002; Horner, 2003). Elevated GC levels elicited by acute stress repress the CA-induced production of proinflammatory cytokine by Th1 cells through GR. The present review will address the potential interactions between contaminants, stress and the immune system in marine mammals at the molecular level. It will not deal with the possible role of stress on the high cancer rates seen in some populations of marine mammals (Martineau et al., 2002). The latter will be addressed elsewhere (Martineau, in preparation).

Immune system: A review

The immune system is classically divided in two major branches, innate and adaptive. The innate branch, constantly in standby alert to defend the body against microorganisms or trauma, is not antigen (Ag)-specific, and has no memory of previous encounters with microorganisms, e.g. it reacts the same way regardless of the number or extent of previous encounters. Most of those microorganisms that invade the body are quickly eliminated by the members of the innate system, monocytes/macrophages, neutrophils and natural killer (NK) cells, through acute inflammation. Acute inflammation is characterized by increased vascular permeability resulting of the action of histamine and bradykinin, but also of interleukin (IL)-1 and Tumor Necrosis Factor alpha (TNF-α). The latter two molecules, "IL-1-like cytokines", are produced by local macrophages, and are major actors of inflammation, for which they are called proinflammatory cytokines. IL-1-like cytokines also induce the expression of adhesion molecules by endothelium used by neutrophils to adhere to the walls of capillaries adjacent to inflamed sites. Interleukin (IL)-8, a molecule also synthesized by endothelial cells,

has complex effects on neutrophils, resulting in their firm adhesion to vascular walls and sequestration at the inflammatory site. Then neutrophils traverse these walls to migrate into damaged tissues which become infiltrated – and destroyed – by large numbers of neutrophils.

If acute inflammation cannot eliminate the aggressing microorganism, and/or if damages are too heavy, chronic inflammation ensues after several days. Neutrophils are progressively replaced by extensive numbers of monocytes/macrophages which engulf and kill microorganisms, and clean up tissue debris. Lymphocytes and fibroblasts accompany macrophages (fibroblasts synthesize collagen, a major component of fibrous (scar) tissue).

Simultaneously, macrophages and dendritic cells (DC) (specialized macrophages), also produce IL-12, which triggers the production of interferon (IFN)-γ by lymphocytes. In turn, IFN-γ further increases the ability of macrophages to kill microorganisms. Macrophages start presenting antigens to $CD4^+$ naïve T cells, a lymphocyte subpopulation. The IL-1 and TNF-α produced by macrophages also activate these lymphocytes, thus launching the first steps of an immune response.

In contrast to the innate branch, the adaptive branch is antigen (Ag) specific and is endowed with memory, e.g. its cellular members (lymphocytes and their products) recognize a given Ag a long time after they first encounter it. Antigen presenting cells (APCs) e.g. macrophages, dendritic cells (DC) and B cells, phagocyte foreign invaders such as bacteria, and break them down into minute fragments which are physically presented on their surface to $CD4^+$ T cells. DCs are the most efficient APCs and the most important in activating lymphocytes. On the APC surface, the Ag is presented within a cleft of certain surface proteins called major histocompatibility complex (MHC) molecules. This encounter causes undifferentiated ($CD4^+$) T cells to produce one of two distinct cytokine patterns, Th1 or Th2. The Th1 pattern, generally seen as pro-inflammatory, is directed at intracellular invaders such as viruses and certain bacteria. The Th2 pattern, broadly considered as anti-inflammatory, is central to humoral immunity (or "antibody-mediated" immunity). Antibodies are most efficient at fighting extracellular parasites such as helminthes (ex.: nematodes, cestodes, trematodes) and most pathogenic bacteria.

Th1 and Th2 are mutually antagonistic. For instance, Th1 differentiation is inhibited by IL-4, the major Th2 cytokine involved in differentiating T cells into Th2 cells (IL-4 is produced by Th2 lymphocytes, mast cells and eosinophils). The severity of tissue destruction in an organ or at a particular anatomical site during an attack by a pathogenic agent is the result of the Th1/Th2 balance prevailing at that site (with a high ratio being synonymous of severe tissue damage). A third category of T cells (T reg) has a negative regulatory effect on both Th1 and Th2 cells by the production of transforming growth factor (TGF)-β.

Which pattern will be followed depends among other factors on the type of APC (there are many types of DC and macrophages), the nature of the presented Ag, and the local relative concentrations of other cytokines. The production of IL-12 by APCs, mostly by DC, plays a central role in the differentiation of T cells into Th1 cells. Th1 cells are responsible for cell-mediated immunity; they release

cytokines among which IL-2 is central for macrophages and cytotoxic T cells ($CD8^+$) activation. Cytotoxic T cells ($CD8^+$) are lymphocytes committed in killing otherwise normal host cells infected by viruses or intracellular bacteria and abnormal host cells such as tumor cells.

Th2 cells produce a battery of cytokines (IL-4, -5, -9 and -13) that help B cell differentiating into antibodies-(IgE) producing cells. Other cytokines involved in Th1 to Th2 differentiation include CCL1 (CC- chemokine ligand 1), which plays a role in cardiovascular diseases and allergic diseases such as asthma.

IFNs are an essential part of the innate system that participates also to the adaptive system, for instance by increasing MHC proteins expression. These molecules are released in the microenvironment where they have an effect on the cells that produce them (autocrine effect) as well as on adjacent cells (paracrine effect). All those cells become protected against viral infection (interferons *interfere* with viral infection) among other effects. IFNs are classified in two groups: type I group is composed of IFN α, β and ω, which are produced by almost all cell types mainly to protect against viral infection. Their expression is partially under the control of transcription factors nuclear factor kappa B (NF-κB), interferon regulator factors (IRF)-3 and other transcription factors (IRF-3 activation itself is triggered by viral infections). Reciprocally, the expression of type I IFNs leads to IRF-3 activation, resulting in a positive feedback loop (Jonasch & Haluska, 2001).

Type II IFNs are composed of a single member, IFNγ, which plays a central role in inducing the Th1 pattern. IFNγ is produced by APCs (among which DCs are the most important), Th1 cells and NK cells. Along with IL-12, IFNγ helps differentiating T cells into Th1 cells, and the latter in turn produce more IFNγ. As importantly, IFNγ activates macrophages in at least two ways: it enhances the capacity of macrophages to kill intracellular parasites, and triggers the production of IL-12, -6 and -18 by macrophages, which further increases Th1 differentiation.

. NF-κB is a family of five transcription factors: NF-κB1 (p105/p50), NF-κB2, RelA, RelB and c-Rel, all involved in inflammation. All members form homo- or heterodimers which repress or activate the expression of a plethora of mammalian pro-inflammatory genes such as IL-1, -2, -4, -8, -12, IL-2R, and others. NF-κB1 and NF-κB2 homodimers decrease the transcription of these pro-inflammatory genes whereas RelA and RelB activate it. NF-κB members are implicated in IL-12 expression by APC, and thus are essential to Th1 differentiation. They also play a central role in innate immunity, inflammation and infection, suppression of lymphocyte apoptosis (programmed death), and DC development (Caamaño & Hunter, 2002). Inactive NF-κB lies in the cytosol bound to IκB, an inhibitor. Various factors such as cytokines and growth factors, or cellular stresses such as bacteria and viruses, trigger the phosphorylation of IκB, which then releases NF-κB. The latter translocates to the nucleus where, like GR and the AhR, it recognizes specific DNA sequences, appropriately named κB sequences.

Glucocorticoid receptor

GC-mediated GR activation accounts for the anti-inflammatory effects of GCs. Activated GR blocks the expression of all pro-inflammatory cytokines such as IL-1 and Th1 cytokines, leaving intact the production of "anti-inflammatory" Th2 cytokines. Thus GCs protect cells and tissues from damages inflicted by exaggerated cell-mediated Th1-type immune response (Ramirez, Fowell, Puclavec, Simmonds, & Mason, 1996; Sapolsky et al., 2000). Liganded GR also activates the transcription of anti-inflammatory proteins such as Clara cell protein 10, IL-1 receptor antagonist, lipocortin, mitogen-activated protein kinase phosphatase-1, neural endopeptidase, and serum leukoprotease inhibitor. Liganded GR activates these genes by binding DNA, specifically the GRE sequences located in the regions that control the expression of these genes.

GR-mediated repression of Th1 functions is mainly exerted through transcriptional repression of at least three pro-inflammatory transcription factors, NF-κB, IRF-3, and AP-1 (the latter is a complex made of two nuclear molecules, c-fos and c-jun). The liganded GR represses the transcription of these factors by protein-protein interactions, not by binding DNA elements. Most of these anti-inflammatory effects are mediated by interactions between liganded GR α and NF-κB. It has been hypothesized that NF-κB may compete with GR for coactivator molecules necessary for the transcription of genes targeted by both activated GR and NF-κB. These two coactivators, "Steroid receptor coactivator-1" (SRC-1) and "p300/CBP", are responsible for making gene promoters accessible to the transcription machinery by acetylating histones. Importantly, SRC-1 and p300/CBP also bind the AhR, a cellular receptor which mediates the toxicity of many contaminants. In addition, p300/CBP also binds IRF-3, suggesting that competition for coactivators could occur between GR, NF-κB and AhR (Smoak & Cidlowski, 2004; Tian, Rabson, & Gallo, 2002). IRF-3 augments IFN α and β transcription and also elevates the transcription of other pro-inflammatory genes such as Il-15 and RANTES, a chemoattractant of eosinophils and monocytes (Hiscott et al., 1999; Taniguchi, Ogasawara, Takaoka, & Tanaka, 2001). The activated GR becomes tethered to DNA-bound IRF-3, and inhibits the transcription of IRF-3 target genes (Kassel & Herrlich, 2007).

Elevation of GC circulating levels prior to exposure to loud noise protects the inner ear from audiogenic trauma and conversely, a failure to elevate GC levels prior to or during audiogenic trauma increases damages (Canlon et al., 2007). In contrast, chronic stress, which results from repeated or prolonged exposure to a stressor and leads to prolonged adrenocortical stimulation by ACTH and exposure to high GC levels, has deleterious effects on most organs, especially on the brain and the immune system (Table 1) (McEwen, 1998; Sapolsky et al., 2000; Romero & Butler, this issue). Note that sustained high levels of ACTH are correlated morphologically with hyperplasia and hypertrophy of the adrenal cortex (Ulrich-Lai et al., 2006). For instance, suicide victims, patients suffering depression and captive non human primates exposed to social stress all show an increase of adrenal mass due to chronic stress (Swaab, Bao, & Lucassen, 2005).

Table 1
Similarities between glucocorticoid receptor (GR) and aryl hydrocarbon receptor (AhR).

Characteristic	GR	AhR	Reference
Function	Nuclear receptor for endogenous hormone, glucocorticoid (released under physiological stress).	Nuclear receptor for xenobiotic. Regulate (enhance) exogenous compound metabolism.	Hahn, 2002; Escriva, Safi, Hänni, et al., 1997; Tian et al., 2002.
	Important for development		
Intracellular location	Intracytoplasmic. Ligand- activated migration to nucleus		
Constitutive ligand	hsp90		
Ligand hydrophobicity	Hydrophobic		
Other ligands	NF-κB		
Target sequence	GRE	DRE (dioxin responsive element) or Xenobiotic responsive element (XRE)	
Natural endogenous ligands	Glucocorticoids	Unknown	
Targets	Multiorgans		
Effects timescale	Prolonged		
Major immune cells targets	T cells		
Selected effects of long term ligand-mediated activation	Immune suppression (T-cell apoptosis and decreased thymus development)	T cells, B cells, dendritic cells	Kerkvliet, 2002
	CYP induction		Herold, McPherson, & Reichardt, 2006. McMillan, McMillan, Glover, et al., 2007.
	Neurotoxicity		Hahn, 2002; Wang, Faucette, Gilbert et al., 2003.
	Diabetogenic		De Kloet, Vreugdenhil, Oitzl et al., 1998; Williamson, Gasiewicz, & Opanashuk, 2005.
			Buckingham, 2006; Remillard & Bunce 2002; Matsumara, 1995.

Stress in cetaceans

Most studies carried out on captured cetaceans to measure stress-induced elevation of GCs suffer drawbacks, some of which are inherent to cetaceans: basal cortisol values are low, interindividual variations are wide, and increases in cortisol levels following stress exposure are lower than those seen in terrestrial mammals. Other drawbacks are inherent to wildlife studies: a long interval may elapse between chase/capture and sampling time, which makes difficult determining basal cortisol levels (Bossart, Reidarson, Dierauf, & Duffield , 2001; Ortiz & Worthy, 2000; St. Aubin et al., 2001; St Aubin, 2001; St Aubin & Dierauf, 2001; St Aubin, 2002 a, b). In spite of these problems, elevated cortisol levels have been associated with stressors in marine mammals and in Eastern Tropical Pacific (ETP) dolphins which are captured after the intensive chase involved in tuna fishing (Bossart et al., 2001; St. Aubin, Ridgway, Wells, & Rhinehart, 1996; St Aubin, 2002 a, b). Chased ETP dolphins showed typical evidences of acute stress such as elevated circulating GC levels, high circulating levels of glucose, decreased circulating levels of iron, thyroid hormone levels, and the presence of a typical "stress leukogram" (increased number of circulating white blood cells due to neutrophils, and decreased numbers of lymphocytes and eosinophils). Other evidences of acute stress seen in these animals were clearly deleterious, such as the observed necrosis of cardiac muscle fibers, probably due to catecholamine overload (Cowan & Curry, 2002; St. Aubin, 2002 a, b).

In porpoises (*Pocoena phocoena*), Th1 proinflammatory cytokines levels were lower and cortisol levels were higher in accidentally captured animals than in captive animals. This difference was consistent with the switch from the Th1 proinflammatory to the immunosuppressive Th2 cytokine pattern seen in response to stressors (and high cortisol levels) in laboratory animals and humans (Fonfara, Siebert, & Prange, 2007; Fonfara, Siebert, Prange, & Colijn, 2007).

Anthropogenic background noise has increased tremendously in oceans over the last decades because of increased maritime traffic and exploration for and exploitation of oil and natural gas. Cetaceans are sensitive to seismic air and waterguns used for these industrial activities (Finneran, Schlundt, Dear, Carder, & Ridgway, 2002). Papers presented in this issue and other studies indicate that both diffuse (e.g. background) and source noises impact the behavior, social communications and navigation of free-ranging cetaceans, and presumably cause stress in these animals (Aguilar Soto et al., 2006; Fair & Becker 2000; Finneran et al., 2002; Foote, Osborne, & Hoelzel, 2004; Hatch & Wright, this issue; Ridgway, et al., 2001; Schlundt, Finneran, Gardner, & Ridgway, 2000; Wright et al., this issue, b). Anthropogenic sound is likely to impact whales even in the deep ocean because it can be transported over thousands of miles, and even deep diving whales can be impacted because high hydrostatic pressures prevailing at great depth do not decrease the hearing acuity of whales (Ridgway et al., 2001). Whether high cortisol levels due to noise or to other stresses can protect whales' inner ear from noise-induced damage is of course highly speculative at this point.

Contaminants and immunosuppression in cetaceans

Some populations of cetaceans are severely affected by multiple anthropogenic stressors. Cetaceans are long lived animals which occupy top positions of the food chain, and whose body is composed of a high percentage of lipids. Thus, it is not surprising that lipophilic contaminants widespread in the food chain and resistant to metabolism accumulate at very high levels in the tissues of these animals. In addition, contaminant levels are often higher in juvenile animals than in adults because contaminants are transferred to newborns from females through cetaceans' lipid-rich milk (Hickie et al., 2000; Martineau, Béland, Desjardins, & Lagacé, l987).

The beluga whale population which inhabits the St Lawrence Estuary (SLE), Quebec, Canada, was severely reduced by hunting from about 7,800 in 1866 to a current estimate of 1,100 animals (Standard error = 300, 95 % confidence interval = 500-1,800) (Department of Fisheries and Oceans Canada, 2007). The population has failed to recover although hunting ended in 1979. Systemic examinations of stranded carcasses started in 1982 have shown that these animals are severely contaminated by lipophilic contaminants compared to Arctic beluga whales. Many of these compounds are known immunosuppressors that often target the adrenal glands, the final effectors of all stress responses (De Guise, Martineau, Béland, & Fournier, 1998; Letcher, Klasson-Wehler, & Bergman, 2000a; Letcher et al., 2000b; Martineau et al., l987; Martineau et al., 1988; Martineau et al., 2002; Martineau, Mikaelian, & Lapointe, 2003).

SLE beluga whales also suffer a variety of opportunistic infections and parasite infestations, suggesting that they are immunosuppressed. In marine mammals, contamination with DRPBs has long been associated with immunosuppression. DRPBs-induced immunosuppression has been suspected to play a role in making harbor seals (*Phoca vitulina*) more sensitive to phocine morbillivirus. These viruses killed more than 20,000 harbor seals in 1988 in the Baltic Sea. Significantly higher tissular concentrations of polychlorinated biphenyls (PCBs) were measured in striped dolphins (*Stenella coeruleoalba*) affected by the 1990-92 morbillivirus epizootic in the Mediterranean Sea, compared to concentrations observed in previous and later years. This difference led to the conclusion that DRPBs may have impaired the dolphins' immune response to the viral infection (Aguilar & Borrell, 1994). A similar association between morbilliviral infection and high OC tissular levels has been observed in common dolphins (*D. delphis ponticus*) from the Black Sea (Birkun et al., 1999).

Young harbor seals fed for 2.5 years with fish contaminated with DRPBs and other pollutants showed compromised immune functions when compared with a group of seals fed with less contaminated fish (reviewed in van Loveren, Ross, Osterhaus, & Vos, 2000). Harbour porpoises stranded in the UK showed a significant, positive association between PCB levels and the number of nematodes infecting them (Bull et al., 2006). In porpoises whose blubber showed total PCB concentration above 17 µg/g, total PCBs levels were significantly more elevated in animals dying of infectious diseases than in those dying from trauma. Below a 17 µg/g concentration, there was no correlation, suggesting that PCB-induced

immunosuppression increases the frequency of infectious diseases (Jepson et al., 2005). PCB concentrations in the SLE population are higher than this putative threshold.

Deficits in immune functions are difficult to evaluate directly in free-ranging cetaceans, largely owing to the problems associated with rapidly obtaining and processing samples in the field. A logical approach to show that the immune functions of a given population are impaired would be comparing its immune parameters to those of a control population less exposed to pollutants. Many factors render such a comparison difficult: populations unexposed to pollutants probably do not exist, the inaccessibility of some populations, which introduce variables in the time required to collect and process samples, the stress of capture, which triggers cortisol release, and genetic differences. An indirect approach - measuring a pollutant dose-response effect - allows avoiding these drawbacks. In free-ranging harbor seals, the ability of lymphocytes to proliferate when stimulated by mitogens was negatively correlated with PCB concentrations. In dolphins, increased concentrations of PCBs and DDT in blood were shown to be inversely correlated with lymphocyte responses (Lahvis et al., 1995). Another approach consists in measuring the *in vitro* response of immune cells from a presumably "normal" population to pollutants added in concentrations identical or similar to those found in the tissues of contaminated animals from the same species. The proliferative response of beluga lymphocytes to mitogens and their spontaneous proliferation are impaired *in vitro* by exposure to concentrations of p,p'-DDT and PCB 138 similar to those found in tissues of SLE beluga (PCB 138 is one of the most abundant PCB congeners present in SLE beluga tissues) (De Guise et al., 1998). Measurements of cytokine production by stimulated phocid (*Phoca vitulina*) lymphocytes similarly exposed *in vitro* to DRPBs and PAHs showed a decrease in IL-2 production, suggesting that DRPBs might impair one of the major very first steps of cell-mediated immune response (Neale, Kenny, Tjeerdema, & Gershwin, 2005).

Beluga and other marine mammals are contaminated with a complex mixture of PCB congeners, distinct compounds and their metabolites. Such mixtures affect not only lymphocyte functions but also phagocytic cells such as neutrophils and monocytes in humans, beluga and dolphins (Levin, Morsey, Mori, & De Guise, 2004; Levin, Morsey, Mori, Nambiar, & De Guise, 2005a, b; Mori, Morsey, Levin, Nambiar, & De Guise, 2006). *In vitro* exposure of phocid macrophages to PCB and PAH caused decreased IL-1β production (Neale et al., 2005).

Contaminants, cytokines and stress

Similarly to GCs' effects, DRPBs' effects are prolonged and are mediated through an intracytoplasmic receptor, the AhR, for which DRPBs have enormous affinity (Barouki, Coumoula, & Fernandez-Salgueroc, 2007) (Table 1). Similar to the GR, the AhR is widely distributed in many organs and cell types, and often has contradictory effects, depending on cell type and organ. Many of these effects are

mediated through AhR binding to NF-κB, which leads either to NF-κB activation or inhibition depending on cell type and previous cell stimulation.

Historically, the AhR was first described as a sensor of exogenous contaminants such as DRPBs and PAHs (Denison & Nagy, 2003). AhR binding to these contaminants triggers a complex cellular response resulting in increased expression of cytochrome P450 (CYP) enzymes, enzymes involved in the degradation of various endogenous and xenobiotic compounds. Like GRs, which are constantly exposed to endogenous GCs in most animals and humans, AhRs are constantly exposed to their ligands, DRPBs, because these compounds are now ubiquitous in the environment and in the tissues of animals and humans (Savouret, Berdeaux, & Casper, 2003).

In the absence of a ligand, the AhR, like the GR, rests inactive in the cytosol, bound to several proteins among which hsp90, the same ligand that binds the GR. Upon binding DRPBs, AhR dissociates from hsp90 and translocates to the nucleus, where, like the liganded GR, it binds a specific DNA sequence, the xenobiotic responsive element (XRE). The XRE is present within the promoters of multiple genes, among which CYP1A1 (Table 1). Intracytoplasmic CYP1A1 generates many highly reactive metabolites from benzo[a]pyrene (B[a]P) (these metabolites, not B[a]P *per se*, are responsible for the powerful carcinogenicity of B[a]P). Beluga and seal AhRs have been cloned, and both show a high affinity for DRPBs, comparable to that of mice strains susceptible to DRPB toxicity, and thus these species should show the same susceptibility to DRPBs toxicity (humans are less susceptible to dioxin toxicity than rodents because the human AhR shows a weaker affinity for DRPBs) (Jensen & Hahn, 2001; Kim, Hahn, Iwata, Tanabe, & Miyazaki, 2002). As demonstrated *in vivo* in laboratory rodents, AhR gene expression can be induced in presence of DRPBs. Consistent with this finding, a "dose-response" relation has been found in the livers of free-ranging contaminated Baikal seals: AhR mRNA levels were proportional to DRPBs tissue concentrations (Kim,et al., 2005).

Ligand-activated AhR can interfere with GCs' effects in many ways depending on cell type, tissue, species, and on the duration of DRPB exposure (Ruby, Leid, & Kerkvliet, 2002). In order to increase the transcription of their target genes, the AhR, GR and NF-κB must bind certain transcriptional coactivators and corepressors. Two AhR coactivators, SRC-1 and p300/CBP, also bind the GR. In addition, p300/CBP also binds IRF-3 (Servant, Grandvaux, & Hiscott, 2002; Smoak & Cidlowski, 2004; Swanson, 2002; Tian et al., 2002). Although competition between GR and NF-κB for these coactivators does not seem to be involved in NF-κB repression by GR, it is possible that, when a combination of stress, inflammation, viral infection and DRPBs occur[1], together AhR, GR and NF-κB compete for SRC-1 and p300/CBP and possibly for other transcription factors such as the GR interacting protein 1 (GRIP-1) (Kassel & Herrlich, 2007).

[1] The infection of DRBPs-contaminated cetaceans by viruses is well documented (Aguilar & Borrell, 1994; Kassel & Herrlich, 2007).

Through AhR binding, DRPBs affect macrophages, DCs, T and B cells, all actors central to innate and adaptive immunity. For instance, liganded AhR triggers the expression of pro-inflammatory cytokine genes in human macrophages, whereas it triggers apoptosis in T cells and DCs (Camacho, Singh, Hegde, Nagarkatti, & Nagarkatti, 2005; Ruby, Funatake, & Kerkvliet, 2004; Vogel, Sciullo, & Matsumara, 2007). All lymphoid organs, especially the thymus, are affected (thymus, spleen, lymph nodes). DRPBs affect B cells directly, and probably impair T cells both directly and indirectly. Dioxin exposure also results in the appearance of a T reg cell subpopulation in mice (Funatake, Marshall, Steppan, Mourich, & Kerkvliet, 2005). Together these perturbations explain that rodents experimentally intoxicated with dioxin are more susceptible to a wide variety of infectious agents.

DRPBs cause chronic inflammation (more specifically macrophage infiltration) in many organs probably because these compounds increase proinflammatory cytokines (Fan, Yan, Wood, Viluksela, & Rozman, 1997; Nyska et al., 2004; Pande, Moran, & Bradfield, 2005; Vogel et al., 2004; Vogel, Nishimura, Sciullo, Wong, & Matsumura, 2007a; Vogel, Sciullo, & Matsumura, 2007b). In primary human macrophages and in a human macrophage cell line, DRPBs increase the production of a battery of pro-inflammatory cytokines (IL-1β, B cell activating factor of the tumor necrosis factor family (BAFF), B lymphocyte chemoattractant (BLC), IRF3, CCL1, TNF-α, and IL-8) (Diaye et al., 2006; Vogel et al., 2004; Vogel et al., 2007a; b). In contrast, DRPBs seem to have severe negative effects on DCs. In mice primary DCs, dioxin decreases the nuclear translocation and binding to κB DNA sequences of NF-κB, leading to accelerated maturation and apoptosis (Ruby et al., 2004). It should be kept in mind that these experiments vary in many respects, among which the animal species, the cell type and the lack or presence of cytokine-mediated cell activation. For instance, Vogel, Sciullo, & Matsumara (2007b) used an unstimulated human macrophage cell line in which RelB and AhR cDNA were transfected, whereas in contrast, a non transfected DC line from mice, activated by TNF-α, was used by Ruby et al. (2002).

In marine mammals, DRBPs exposure seems to decrease IL-1 production by macrophages. Peripheral blood mononuclear cells (PBMC) (monocytes and lymphocytes isolated from blood) from 4 free-ranging harbor seals captured from the wild were exposed to PCB congener 169, a DRBP. This exposure significantly decreased IL1-β production. This result is in apparent contradiction with one of the above study where IL-1 β production was increased (Vogel et al., 2004). Again, many differences in the protocols used may explain this discrepancy. Firstly, no time course measurements were carried out in the seal study, e.g. phocid IL-1 was measured only after 4-hour incubation. Thus an increase in IL-1 levels would have been missed if it occurred 4 hours after exposure. This is a serious concern given that the increase in IL-1 production seen in human macrophages was detected 6 hours post exposure (Vogel et al., 2004). Secondly, the contaminant concentrations used in the two experiments were widely different: seals PBMCs were exposed to a 20-μM concentration of PCB congener 169 whereas the human macrophage cell line was exposed to 10-nM dioxin. Accounting for PCB 169 toxic equivalency

factor (0.01), phocid seal PBMCs were exposed to a dioxin toxicity level 20 times higher than that used for the human macrophages. Thirdly, PBMCs are composed of lymphocytes and monocytes. Thus decreased IL-1β production could have been due to Th1 activity by the lymphocytes present in the cell mixture because Th1 activity represses IL-1β production by macrophages. Fourth, PBMCs could have been impacted by the high plasma cortisol levels expected from capture especially considering that PBMC were isolated up to 8 h after capture (Neale et al., 2005). Finally variation in species susceptibility to dioxin toxicity may also contribute to these apparently conflicting results.

In wildlife, PCB-contaminated fish provided some of the first hints that GC and AhR cellular pathways are somewhat related. Upon capture, PCB-contaminated fish did not show the expected elevated cortisol levels that capture normally triggers in noncontaminated fish (Hontela, Rasmussen, Audet, & Chevalier, 1992; Hontela, 2005). Recent experiments carried out in fish have provided mechanistic explanations for these early observations. In contaminated fish, AhR activation decreases GC synthesis by inhibiting two key proteins involved in two rate-limiting steps of the GC synthesis, first the steroidogenic acute regulatory protein (StAR), which transports cholesterol to the mitochondrial inner membrane and second, the cholesterol side chain cleavage (P450scc or CYP11A1/scc) enzyme, which converts cholesterol to pregnenolone, the first step of cortisol synthesis. In other words, AhR-ligand contaminants hamper one of the major adaptive responses to stress. Considering that both cortisol synthesis pathways and proteins involved in GC synthesis are highly conserved in animals, most likely these findings can be applied to higher vertebrates (Aluru & Vijayan, 2006). DRPBs metabolites can also bind the GR, competing with endogenous GCs and inhibiting GC synthesis (Brandt, Joensson, & Lund, 1992; Durham & Brouwer, 1990; Johansson, Nilsson, & Lund, 1998). Moreover AhR also mediates the endocrine disruption associated with DRPBs toxicity: among other effects, liganded AhR triggers the destruction of the estrogen and androgen receptors (ER and AR) through ligation with ubiquitin (Ohtake et al., 2007). The ER, AR and GR are all members of the superfamily of nuclear hormone receptors because of the many structural and functional similarities they share. For instance, in prostate cancer patient, an AR double mutant could bind cortisol (Zhao et al., 2000). Because of these similarities, it is possible that AhR also causes GR degradation.

DRPBs adrenal toxicity

Many OCs and their metabolites also severely damage the adrenal glands, the final effector organs of stress. There are several reasons why adrenal glands are vulnerable to these compounds. The vascular supply of the adrenal cortex is disproportionately large compared to the adrenals' mass. In addition, the adrenal cortex is rich in both lipids and CYP enzymes because it synthesizes steroids from cholesterol, which explains why adrenals accumulate high concentrations of lipophilic contaminants, which are then metabolized into more toxic molecules by the CYP enzymes (Harvey & Everett, 2003).

Degenerative and proliferative changes consistent with chronic stress and DRPBs intoxication are commonly observed in the adrenal cortex and medulla of SLE and Western Hudson Bay beluga whales and the severity of these lesions increases with age in both populations. The younger age of much less contaminated control beluga whales sampled from Hudson Bay precluded a comparison of lesion severity and prevalence between age-matched groups (Lair et al., 1997).

According to existing reports, adrenocortical cysts are rare in marine mammals except in SLE beluga and white-sided dolphins (Geraci & St. Aubin, 1979; Lair et al., 1997). In white-sided dolphins, these lesions were attributed to sinusoidal blockage or hypersecretion, and were considered associated with stress related with reproductive functions since 100 % of females and only 20 % of males were affected. No lesions have been observed in the adrenal glands of other Odontocetes species beside increased medullary and/or cortical mass in Atlantic bottlenose dolphins (*Tursiops truncatus*) and harbour porpoises (*Phocoena phocoena*) with chronic stress (Clark, Cowan, & Pfeiffer, 2006; Kuiken et al., 1993). These observations suggest that the rarity of adrenal lesions in cetaceans other than beluga and white-sided dolphins is not artifactual.

Several evidences suggest that OC metabolites may cause adrenal cysts. The toxicity of OCs metabolites for the adrenal cortex such as O,p'DDD, noticed during early toxicity assessments of DDT, has long been used for the treatment of pathological adrenal cortex hypersecretion (Cushing syndrome) in both human and veterinary medicine (Hart, Reagan, & Adamson, 1973; Rijnberk, 1996). Other OC metabolites such as $MeSO_2OC$ are adrenocorticolytic in rodents, and some of these compounds, such as 3-$MeSO_2$-4,4'-DDE, compete with GRs and inhibit GC synthesis (Brandt et al., 1992; Durham & Brouwer, 1990; Johansson et al., 1998). In grey and harbor seals from the Baltic Sea, adrenocortical hyperplasia has been attributed to contamination with PCB and DDT based on epidemiological data (Bergman & Olsson, 1985; Olsson, 1994; Olsson, Karlsson, & Ahnland, 1994). In Baltic grey seals, 3-$MeSO_2$-PCB levels were highest in females with adrenocortical hyperplasia (Haraguchi, Athanasiadou, Bergman, Hovander, & Jensen, 1992), a sex distribution reminiscent of that seen in Atlantic white-sided dolphins affected by adrenal cysts.

Both SLE beluga and Atlantic white-sided dolphins are contaminated with high amounts of OCs and their metabolites (Martineau et al., l987; McKenzie, Rogan, Reid, & Wells, 1997; McKinney et al., 2006; Muir et al., 1996; Troisi, Haraguchi, Simmonds, & Mason, 1998). High blubber concentrations of $MeSO_2$-PCB and $MeSO_2$-DDE have been detected in SLE beluga. In fact, these concentrations are the highest among cetaceans, including Hudson Bay beluga (the concentrations found in SLE beluga are also higher than those found in humans exposed to PCB during the Yusho industrial accident) (Letcher et al., 2000 a, b). SLE beluga and white-sided dolphins both form abundant methylsulphones from PCBs. Thus, because of their long life span, both species may have been exposed to high levels of adrenotoxic OC metabolites for decades (Martineau et al., 2003).

There is apparent contradiction between the adrenocortical hyperplasia epidemiologically associated with $MeSO_2$-DDE in seals, and the adrenocortical

degeneration induced by these compounds in laboratory animals and possibly in SLE beluga (Brandt et al., 1992; Jönsson, Lund, Bergman, & Brandt, 1992; Jönsson, Lund, & Brandt, 1993; Jönsson, Rodriguez-Martinez, Lund, Bergman, & Brandt, 1991). Perhaps OC metabolites-mediated degeneration of the adrenal cortex alternates with ACTH-mediated regeneration since in mammals, the destruction of the adrenal cortex and/or the interference with GC synthesis normally triggers the feedback control of the HPA axis. Decreased GC levels due to adrenocortical destruction normally increase the production of ACTH by the pituitary, which leads to hypertrophy (increased cellular size) and hyperplasia (increased cell numbers) of the adrenal cortex in order to reestablish normal serum GC levels. Note that contaminant-induced damage to cortisol-producing cells has been observed in contaminated fish in the St Lawrence River (Hontela et al., 1992; Hontela, 2005; Rijnberk, 1996; Ulrich-Lai et al., 2006). Thus, it is possible that adrenal lesions affect taxonomically divergent species because of environmental exposure to similar adrenotoxic lipophilic compounds.

It is probable that the pathologic effects of ingesting low OCs'doses over decades - such as occurs in free-ranging mammals - differ from those of large single doses typical of toxicity experiments carried out in laboratory animals. SLE beluga, white-sided dolphins, harbour porpoises and Baltic grey seals are exposed to complex and different cocktails of OC compounds which generate different metabolites that alter the distribution and even the nature of each other (van Birgelen, Ross, DeVito, & Birnbaum, 1996). For instance, by contrast to cetaceans, pinnipeds have a high capacity for generating PCB methyl sulphone and have high CYP2B activity (Boon, Oostingh, van der Meer, & Hillebrand, 1994; Reijnders & de Ruiter-Dijkman, 1995; Troisi et al., 1998). The combined pathologic effects of these complex mixtures are probably not the same as those of single compounds or metabolites typically used in toxicological studies. In addition, the effects of toxic xenobiotics vary according to species, sex, genetic background, age and the developmental stage at which experimental animals are first exposed (Jönsson, Rodriguez-Martinez, & Brandt, 1995). For instance, Baltic Grey and Harbor seals contaminated in nature with OC show adrenocortical hyperplasia, a purely proliferative lesion, of which the severity is proportional to tissue OC concentrations whereas in SLE beluga in contrast, a mixture of degenerative and proliferative lesions affects the adrenal cortex (Lair et al., 1997; Olsson et al., 1994). Adrenocortical hyperplasia in harbor porpoises contaminated with OCs is not proportional to their OC tissular levels (Kuiken et al., 1993). This could be related to the relatively higher CYP2B-dependent ethoxyresorufin-*O*-deethylase (EROD) activity or other metabolic differences shared by both harbor porpoises and pinnipeds (reviewed in Martineau et al., 2003).

Conclusion

Noise is a likely source of major stress in marine mammals due to increased anthropogenic activities practiced worldwide in an industrial mode. Stress and some lipophilic contaminants exert their effects through two nuclear receptors, GR and AhR, both present in lymphocytes, and whose functions are

intertwined because they bind common ligands such as NF-κB. For instance, GCs are competed out by some PCB metabolites, and GC synthesis is decreased by AhR activation. In addition, the adrenal glands, the end producers of acute and chronic stress hormones, are themselves the target of some OC metabolites. Thus, it is safe to say that responses to stressors, acute and chronic, are disrupted by at least some OCs and /or DRBPs in contaminated marine mammals. As shown by the seemingly conflicting effects of dioxin exposure on IL-1 production by immune cells from different species, the methods used to assess mechanisms of immunotoxicity *in vitro* have to be standardized in terms of cell types employed (cell line versus primary cells; genetically engineered cells versus non genetically engineered cells; cell mixture versus pure population), duration of exposure (with time course measurements), and contaminants concentration (which should include concentrations found in wild animals) (Neale et al., 2005; Vogel et al., 2004).

Pathologists faced with the task of determining the contributing factors, or the causes of wildlife mortality, rarely have clinical information such as GC circulating or fecal levels. To compensate for this lack, adrenal and pituitary glands of dead or live animals should be examined in details because in animals and people, chronic stress and the accompanying sustained ACTH production over extended periods are expected to lead to macroscopic pathological changes in adrenal glands, of which the most obvious is probably increased mass (Clark, Cowan, & Pfeiffer, 2006; Swaab et al., 2005).

We propose that such baseline data – which could be determined on live animals, by echography or magnetic resonance imaging for instance- would help in assessing the presence of chronic stress when confronted with a declining wildlife population from which it is difficult to extract clinical data (e.g. data from live animals). Concurrently, other means of obtaining GC levels from live animals, such as measuring tissue GCs levels from skin biopsies, should be developed.

To this author's knowledge, there have been no animal toxicity studies to address the effects of stressors on the potential toxicity of environmental contaminants or therapeutic compounds. This is especially true with regards to marine mammals. Yet it is clear from this review that DRPBs can antagonize GC-mediated chronic stress responses: GCs repress the synthesis and release of all proinflammatory cytokines whereas on the contrary, at least in certain cell types, DRPBs increase expression levels of proinflammatory cytokines such as IL-1 β, TNF-α, IL-8, BAFF and of pro-inflammatory transcription factors such as IRF-3. It is also possible that AhR, GR, IRF-3 and NF-κB compete for the same coactivators, and/or that unexpected effects result from cross-talks between these receptors and transcription factors if inflammation, viral infection, DRPB contamination and chronic stress coincide temporally.

Together, the interactions between variable intracellular concentrations of GCs, GR isoforms, mineralocorticoid receptors, cytokines and co-transcription factors such as NF-κB and IRF-3 subtly modulate immune functions during stress, to avoid immune or inflammatory overreactions, or on the contrary to enhance the immune system in order to eliminate microorganisms and/or their toxins (Sapolsky et al., 2000). Any disturbance of this finely tuned system and of its development by xenobiotic compounds through AhR, or by chronic stress through

sustained high GCs levels, is likely to have undesirable consequences on the immune and inflammatory responses. Some of these outcomes might be unexpected. For instance, the inner ear relies on optimal adjustment of GCs, GR and other GR ligands (chaperones, co-chaperones, and modulatory element binding proteins) to avoid damage following audiogenic stressors. The failure to elevate GC levels in response to audiogenic trauma such as those that are likely induced by the intense sound produced by oil exploration might increase damages to the inner ear of cetaceans exposed to such noise (Canlon et al., 2007; Finneran et al., 2002; Horner, 2003).

The exposure to some OCs and to other exogenous stressors such as noise either *in utero* or during early life threatens the integrity of the immature mammalian immune system, and compromise the adaptive response to subsequent stressors. Juvenile cetaceans are often more contaminated than adults because they absorb contaminants from lactating mothers, and some OCs are especially toxic for developing organs such as thymus and brain. Thus juveniles are particularly put at risk by OC contamination and noise.

New or improved conceptual frames for stress have recently emerged (McEwen 1998, 2000; Sapolsky et al., 2000). All confer the HPA axis and its development a central role in the response to stressors. Most consider contaminants as another stressor (Romero, 2004; Sapolsky et al., 2000). Yet at least some of these stressors, DRPBs, target the adrenal glands, the very same organ whose integrity allows mammals to respond adequately to daily stressors.

References

Aguilar, A., & Borrell, A. (1994). Abnormally high polychlorinated biphenyl levels in striped dolphins (*S. coeruleoalba*) affected by the 1990-1992 Mediterranean epizootic. *Science of the Total Environment*, **154**, 237-247.

Aguilar Soto, N., Johnson, M., Madsen, P. T., Tyack, P. L., Bocconcelli, A., & Borsani, J. F. (2006). Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Z. cavirostris*)? *Marine Mammal Science,* **22**(3)**,** 690-699.

Aluru, N., & Vijayan, M. M. (2006). Aryl hydrocarbon receptor activation impairs cortisol response to stress in rainbow trout by disrupting the rate-limiting steps in steroidogenesis. *Endocrinology,* **147**(4)**,** 1895-1903.

Barouki, R., Coumoula, X., & Fernandez-Salgueroc, P. M. (2007). The aryl hydrocarbon receptor, more than a xenobiotic-interacting protein. *FEBS Letters,* **581,** 3608–3615

Bergman, Å., & Olsson, M. (1985). Pathology of Baltic grey seal and ringed seal females with special reference to adrenocortical hyperplasia: Is environmental pollution the cause of a widely distributed disease syndrome? *Finnish Game Research*, **44**, 47-62.

Birkun, A. Jr., Kuiken, T., Krivokhizhin, S., Haines, D. M., Osterhaus, A. D., van de Bildt, M. W., Joiris, C. R., & Siebert, U. (1999). Epizootic of morbilliviral disease in common dolphins (*D. delphis ponticus*) from the Black sea. *Veterinary Record*, **144**, 85-92.

Boon, J. P., Oostingh, I., van der Meer, J., & Hillebrand, M. T. (1994). A model for the bioaccumulation of chlorobiphenyl congeners in marine mammals. *European Journal of Pharmacology*, **270**, 237-251.

Bossart, G., Reidarson, T.H., Dierauf, L.A., & Duffield, D.A. (2001). Clinical Pathology. In L.A. Dierauf & F.M.D. Gulland (Eds.), *Handbook of marine mammal medicine: Health, Disease and Rehabilitation,* Vol. 2 (pp. 383-436). Boca Raton, FL: CRC Press.

Brandt, I., Joensson, C.-J., & Lund, B.-O. (1992). Comparative studies on adrenocorticolytic DDT-metabolites. *Ambio*, **21**(8), 602-605.

Buckingham, J. C. (2006). Glucocorticoids: Exemplars of multi-tasking. *British Journal of Pharmacology*, **147**, S258-268.

Bull, J. C., Jepson, P. D., Ssuna, R. K., Deaville, R., Allchin, C. R., Law, R. J., & Fenton, A. (2006). The relationship between polychlorinated biphenyls in blubber and levels of nematode infestations in harbour porpoises, *P. phocoena*. *Parasitology,* **132**(Pt 4), 565-573.

Caamaño, J., & Hunter, C. A. (2002). NF-kappaB family of transcription factors: Central regulators of innate and adaptive immune functions. *Clinical Microbiology Reviews,* **15**(3), 414-429.

Camacho, I. A., Singh, N., Hegde, V. L., Nagarkatti, M. & Nagarkatti, P. S. (2005). Treatment of mice with 2,3,7,8-tetrachlorodibenzo-p-dioxin leads to aryl hydrocarbon receptor-dependent nuclear translocation of NF-κB and expression of fas ligand in thymic stromal cells and consequent apoptosis in T cells. *The Journal of Immunology,* **175,** 90-103.

Canlon, B., Meltser, I., Johansson, P., & Tahera, Y. (2007). Glucocorticoid receptors modulate auditory sensitivity to acoustic trauma. *Hearing Research*, **226**, 61-69.

Clark, L. S., Cowan, D. F., & Pfeiffer, D. C. (2006). Morphological changes in the Atlantic Bottlenose Dolphin (*Tursiops truncatus*) adrenal gland associated with chronic stress. *Journal of Comparative Pathology,* **135**(4)**,** 208-216.

Cowan, D. D., & Curry, B. (2002). *Histopathological assessment of dolphins necropsied onboard vessels in the Eastern Tropical Pacific tuna fishery.* Administrative report LJ-02-24C. Retrieved July 26, 2007 from http://swfsc.noaa.gov/uploadedFiles/Divisions/PRD/Programs/ETP_Cetacean_Assessment/LJ_02_24C.pdf

De Bosscher, K., Vanden Berghe, W., & Haegeman, G. (2002). The interplay between the glucocorticoid receptor and nuclear factor-κB or activator protein-1: Molecular mechanisms for gene repression. *Endocrine Reviews,* **24**(4)**,** 488-422.

De Guise, S., Martineau, D., Béland, P., & Fournier, M. (1998). Effects of *in vitro* exposure of beluga whale leukocytes to selected organochlorines. *Journal of Toxicology & Environmental Health*, **55**, 479-493.

De Kloet, E. R., Vreugdenhil, E., Oitzl, M. S., & Joëls, M. (1998). Brain corticosteroid receptor balance in health and disease. *Endocrine Reviews*, **19**(3)**,** 269-301.

Deak, T. (2007). From classic aspects of the stress response to neuroinflammation and sickness: Implications for individuals and offspring of diverse species. *International Journal of Comparative Psychology*, **this issue**, 96-110.

Denison, M. S., & Nagy, S. R. (2003). Activation of the Aryl Hydrocarbon receptor by structurally diverse exogenous and endogenous chemicals. *Annual Review of Pharmacology and Toxicology,* **43,** 309-334.

Department of Fisheries and Oceans Canada. (2007). *Lack of Recovery in St. Lawrence Estuary beluga*. Canadian Science Advisory Secretariat. Research Document. ISSN 1499-3848. Retrieved 20 November 2007 from http://www.medssdmm.dfompo.gc.ca/csas/applications/publications/publication_e.asp?year_selected=2007&series=RES.

Diaye, M. N., Le Ferrec, E., Lagadic-ossmann, D., Corre, S., Gilot, D., Lecureur, V., Monteiro, P., Rauch, C., Galibert, M.-D., & Fardel, O. (2006). Aryl Hydrocarbon Receptor- and Calcium-dependent Induction of the Chemokine CCL1 by the Environmental Contaminant Benzo[a]pyrene. *The Journal of Biological Chemistry,* **281**(29)**,** 19906-19915.

Durham, S. K., & Brouwer, A. (1990). 3,4,3',4'-tetrachlorobiphenyl distribution and induced effects in the rat adrenal gland. Localization in the *zona fasciculata*. *Laboratory Investigation*, **62**, 232-239.

Escriva, H., Safi, R., Hänni, C., Langlois, M. C., Saumitou-Laprade, P., Stetehelin, D., Capron, A., Pierce, R., & Laudet, V. (1997). Ligand binding was acquired during evolution of nuclear receptors. *Proceedings of the National Academy of Sciences of the United States of America*, **94**, 6803-808.

Fair, P. A., & Becker, P. R. (2000). Review of stress in marine mammals. *Journal of Aquatic Ecosystem Stress and Recovery*, **7,** 335-354.

Fan, F., Yan, B., Wood, G., Viluksela, M., & Rozman, K. K. (1997). Cytokines (IL-1β and TNFα) in relation to biochemical and immunological effects of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in rats. *Toxicology,* **116,** 9-16.

Finneran, J. J., Schlundt, C. E., Dear, R., Carder, D. A., & Ridgway, S. H. (2002). Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *Journal of Acoustic Society of America*, **111**(6), 2929-2940.

Fonfara, F., Siebert, U., & Prange, A. (2007a). Cytokines and acute phase proteins as markers for infection in harbor porpoises (*P. phocoena*). *Marine Mammal Science*, **23**(4), 931-942.

Fonfara, S., Siebert, U., Prange, A., & Colijn, F. (2007b). The impact of stress on cytokine and haptoglobin mRNA expression in blood samples from harbour porpoises (*Phocoena phocoena*). *Journal of Marine Biologist Association of the United Kingdom,* **87,** 305-311.

Foote, A.D., Osborne, R. W., & Hoelzel, A. R. (2004). Whale-call response to masking boat noise. *Nature*, **428**, 910.

Funatake, C. J., Marshall, N. B., Steppan, L. B., Mourich, D. V. & Kerkvliet, N. I., (2005). Cutting Edge: Activation of the Aryl Hydrocarbon Receptor by 2,3,7,8-Tetrachlorodibenzo-p-dioxin Generates a Population of CD4+CD25+ Cells with Characteristics of Regulatory T Cells. *The Journal of Immunology,* **175,** 4184–4188.

Geraci, J. R., & St.Aubin, D. J. (1979). *Biology of Marine Mammals. Insights through Strandings.* Prepared for: Marine Mammal Commission. MMC-77/13:343. Springfield, VA. U.S. National Technical Information. U.S. Department of Commerce.

Hahn, M. E. (2002). Aryl hydrocarbon receptors: Diversity and evolution. *Chemico-Biological Interactions*, **141**, 131-160.

Haraguchi, K., Athanasiadou, M., Bergman, A., Hovander, L., & Jensen, S. (1992). PCB and methylsulfones in selected groups of seals from Swedish waters. *Ambio*, **21,** 546-549.

Harrison, R. J. (1969). Endocrine organs: Hypophysis, thyroid, and adrenal. In H.T. Andersen (Ed.), *The Biology of Marine Mammals* (pp. 349-390). New York: Academic Press.

Hart, M. M., Reagan, R. L., & Adamson, R. H. (1973). The effect of isomers of DDD on the ACTH-induced steroid output, histology and ultrastructure of the dog adrenal cortex. *Toxicology and Applied Pharmacology*, **24**, 101-113.

Harvey, P. W., & Everett, D. J. (2003). The Adrenal Cortex and Steroidogenesis as Cellular and Molecular Targets for Toxicity: Critical Omissions from Regulatory Endocrine Disrupter Screening Strategies for Human Health? *Journal of Applied Toxicology*, **23**, 81-87.

Hatch, L., & Wright, A. J. (2007). A brief review of anthropogenic sound in the oceans. *International Journal of Comparative Psychology*, **this issue**, 121-133.

Herold, M. J., McPherson, K. G., & Reichardt, H. M. (2006). Glucocorticoids in T cell apoptosis and function. *Cellular and Molecular Life Sciences,* **63,** 60-72.

Hickie, B. E., Kingsley, M. C. S., Hodson, P. V., Muir, D. C. G., Béland, P., & Mackay, D. (2000). A modeling-based perspective on the past, present, and future polychlorinated biphenyl contamination of the St. Lawrence beluga whale (*D. leucas*) population. *Canadian Journal of Fisheries and Aquatic Sciences*, **57** (Suppl. 1), 101-112.

Hiscott, J., Pitha, P., Genin, P., Nguyen, H., Heylbroeck, C., Mamane, Y., Algarte, M., & Lin, R. (1999). Triggering the Interferon Response: The Role of IRF-3 Transcription Factor. *Journal of Interferon and Cytokine Research,* **19,** 1-13.

Hontela, A. (2005). Stress and the hypothalamo-pituitary-interrenal axis: Adrenal toxicology. Effects of environmental pollutants on the structure and function of the HPI axis. In T.W. Moon & T. P. Mommsen (Eds.), *Biochemical and molecular biology of fishes. Vol. 6. Environmental toxicology* (pp. 331-363). Amsterdam: Elsevier.

Hontela, A., Rasmussen, J. B., Audet, C., & Chevalier, G. (1992). Impaired cortisol stress response in fish from environments polluted by PAHs, PCBs, and mercury. *Archives of Environmental Contamination & Toxicology*, **22,** 278-283.

Horner, K. C. (2003). The emotional ear in stress. *Neuroscience and biobehavioral reviews*, **27**, 437-446.

Jensen, B., & Hahn, M. E. (2001). cDNA Cloning and characterization of a high affinity Aryl Hydrocarbon Receptor in a cetacean, the Beluga, *D. leucas*. *Environmental Toxicology*, **64**, 41-56.

Jepson, P. D., Bennett, P. M., Deaville, R., Allchin, C. R., Baker, J. R., & Law, R. J. (2005). Relationships between polychlorinated biphenyls and health status in harbor porpoises (*P. phocoena*) stranded in the UK. *Environmental Toxicology and Chemistry*, **24,** 238-248.

Johansson, M., Nilsson, S., & Lund, B.-O. (1998). Interactions between Methylsulfonyl PCBs and the Glucocorticoid Receptor. *Environmental Health Perspectives,* **106** (12)**,** 769-772.

Jonasch, E., &. Haluska, F. G. (2001). Applications, and toxicities. Interferon in Oncological Practice: Review of Interferon Biology, Clinical applications and toxicities. *The Oncologist*, **6,** 34-55

Jönsson, C. J. Lund, B.-O., & Brandt, I. (1993). Adrenocorticolytic DDT-metabolites: Studies in mink, *M. vison* and otter, *L. lutra*. *Ecotoxicology,* **2,** 41-53.

Jönsson, C.J., Lund, B.-O., Bergman, Å., & Brandt, I. (1992). Adrenocortical toxicity of 3-methylsulphonyl-DDE in mice; 3: Studies in fetal and suckling mice. *Reproductive Toxicology,* **6,** 233-240.

Jönsson, C. J., Rodriguez-Martinez, H., Lund B.-O., Bergman, Å., & Brandt, I. (1991). Adrenocortical toxicity of 3-methylsulfonyl-DDE in mice. II. Mitochondrial changes following ecologically relevant doses. *Fundamental and Applied Toxicology*, **16,** 365-374.

Jönsson, J., Rodriguez-Martinez, H., & Brandt, I. (1995). Transplacental toxicity of 3-methylsulphonyl-DDE in the developing adrenal cortex in mice. *Reproductive Toxicology,* **9,** 257-264.

Kassel, O., & Herrlich, P. (2007). Crosstalk between the glucocorticoid receptor and other transcription factors: Molecular aspects. *Molecular and Cellular Endocrinology,* **275,** 13–29.

Kerkvliet, N. I. (2002). Recent advances in understanding the mechanisms of TCDD immunotoxicity. *International Immunopharmacology*, **2,** 277-291.

Kim, E. Y., Hahn, M. E., Iwata, H., Tanabe, S., & Miyazaki, N. (2002). cDNA cloning of an aryl hydrocarbon receptor from Baikal seals (*P. sibirica*). *Marine Environmental Research,* **54,** 285-289.

Kim, E. Y., Iwata, H., Suda, T., Tanabe, S., Amano, M., Miyazaki, N., & Petrov, E. A. (2005). Aryl hydrocarbon receptor (AHR) and AHR nuclear translocator (ARNT) expression in Baikal seal (*P. sibirica*) and association with 2,3,7,8-TCDD toxic equivalents and CYP1 expression levels. *Comparative Biochemistry and Physiology,* Part C, **141,** 281-291.

Kuiken, T., Höfle, U., Bennett, P. M., Allchin, C. R., Kirkwood, J. K., Baker, J. R., Appleby, E. C., Lockyer, C. H., Walton, M. J., & Sheldrick, M. C. (1993). Adrenocortical hyperplasia, disease and chlorinated hydrocarbons in the harbour porpoise (*P. phocoena*). *Marine Pollution Bulletin,* **26,** 440-446.

Lahvis, G. P., Wells, R. S., Kuehl, D. W., Stewart, J. L., Rhinehart, H. L., & Via, C. S. (1995). Decreased lymphocyte responses in free-ranging bottlenose dolphins (*T. truncatus*) are associated with increased concentrations of PCBs and DDT in peripheral blood. *Environmental Health Perspectives,* **103,** 67-72.

Lair, S., Béland, P., De Guise, S., & Martineau, D. (1997). Adrenal hyperplastic and degenerative changes in beluga whales. *Journal of Wildlife Diseases,* **33**(3)**,** 430-437.

Letcher, R. J., Klasson-Wehler, E., & Bergman, A. (2000a). Methyl Sulfone and hydroxylated metabolites of polychlorinated biphenyls. In J. Paasivirta (Ed.), *The Handbook of Environmental Chemistry. New types of Persistent Halogenated Compounds* (pp. 317-359). Berlin: Springer-Verlag.

Letcher, R. J., Norstrom, R. J., Muir, D. C. G., Sandau, K., Koczanski, R., Michaud, R., De Guise, S., & Béland, P. (2000b). Methylsulfone PCB and DDE metabolites in beluga whale (*D. leucas*) from the St Lawrence River estuary and western Hudson Bay. *Environmental Toxicology & Chemistry,* **19,** 1378-1388.

Levin, M., Morsey, B., Mori, C., & De Guise, S. (2004). Specific non-coplanar PCB-mediated modulation of bottlenose dolphin and beluga whale phagocytosis upon in vitro exposure. *Journal of Toxicology & Environmental Health* A, **67**(19), 1517-1535.

Levin, M., Morsey, B., Mori, C., Nambiar, P. R., & De Guise, S. (2005a). Non-Coplanar PCB-Mediated Modulation of Human Leukocyte Phagocytosis: A New Mechanism for Immunotoxicity. *Journal of Toxicology & Environmental Health*. Part A, **68**(22)**,** 1977-1993.

Levin, M., Morsey, B., Mori, C., Nambiar, P. R., & De Guise, S. (2005b). PCBs and TCDD, alone and in mixtures, modulate marine mammal but not B6C3F1 mouse leukocyte phagocytosis. *Journal of Toxicology & Environmental Health* A, **68**(8)**,** 635-656.

Martineau, D., Béland, P., Desjardins, C., & Lagacé, A. (l987). Levels of organochlorine chemicals in tissues of beluga whales (*D. leucas*) from the Saint Lawrence Estuary, Quebec, Canada. *Archives of Environmental Contamination and Toxicology,* **16,** 137-147.

Martineau, D., Lagacé, A., Béland, P., Higgins, R., Armstrong, D., & Shugart, L. R. (1988). Pathology of stranded beluga whales (*D. leucas*) from the St. Lawrence Estuary, Québec, Canada. *Journal of Comparative Pathology,* **98**(3), 287-311.

Martineau, D., Lemberger, K., Dallaire, A., Labelle, P., Lipscomb, T. P., Michel, P., & Mikaelian, I. (2002). Cancer in Wildlife, a Case Study: Beluga from the St. Lawrence Estuary, Québec, Canada. *Environmental Health Perspectives,* **110**(3)**,** 285-292.

Martineau, D., Mikaelian, I., & Lapointe, J. M. (2003). Pathology of cetaceans. A case study: Beluga from the St Lawrence Estuary. In J. G. Vos, G. D. Bossart, M. Fournier, & T. J. O'Shea (Eds), *Toxicology of Marine Mammals* (pp. 333-380). London and New York: Taylor & Francis Publ..

Matsumura, F. (1995). Mechanism of action of dioxin-type chemicals, pesticides, and other xenobiotics affecting nutritional indexes. *American Journal of Clinical Nutrition*, **61,** 695S-701S.

McEwen, B. S. (2000). Allostasis and Allostatic Load: Implications for neuropsycho-pharmacology. *Neuropsychopharmacology,* **22,** 108-124.

McEwen, B. S. (1998). Protective and damaging effects of stress mediators. *New England Journal of Medicine,* **338**(3), 171-179.

McKenzie, C., Rogan, E., Reid, R. J., & Wells, D. E. (1997). Concentrations and pattern of organic contaminants in Atlantic white-sided dolphins (*L. acutus*) from Irish and Scottish coastal waters. *Environmental Pollution,* **98,** 15-27.

McKinney, M. A., De Guise, S., Martineau, D., Béland, P., Lebeuf, M., & Letcher, R. J. (2006). Organohalogen contaminants and metabolites in beluga whale (*D. leucas*) liver from two Canadian populations. *Environmental Toxicology and Chemistry,* **25**(5)**,** 1246-1257.

McMillan, B. J., McMillan, S. N., Glover, E., & Bradfield, C. A. (2007). 2,3,7,8-Tetrachlorodibenzo-p-dioxin Induces Premature Activation of the KLF2 Regulon during Thymocyte Development. *The Journal of Biological Chemistry,* **282**(17)**,** 12590–12597.

Mori, C., Morsey, B., Levin, M., Nambiar, P. R., & De Guise, S. (2006). Immunomodulatory effects of in vitro exposure to organochlorines on T-cell proliferation in marine mammals and mice. *Toxicology & Environmental Health A,* **69,** 283-302.

Muir, D. C. G., Ford, C. A., Rosenberg, B., Norstrom, R. J., Simon, M., & Briand, P. (1996). Persistent organochlorines in beluga whales (*D. leucas*) from the St. Lawrence River Estuary- I. Concentrations and patterns of specific PCBs, chlorinated pesticides and polychlorinated dibenzo-p-dioxins and dibenzofurans. *Environmental Pollution*, **93**(2), 219-234.

Neale, J. C. C., Kenny, T. P., Tjeerdema, R. S., & Gershwin, M. E. (2005). PAH- and PCB-induced alterations of protein tyrosine kinase and cytokine gene transcription in harbour seal (*Phoca vitulina*) PBMC. *Clinical & Developmental Immunology,* **12**(2), 91-97.

Nyska, A., Jokinen, M. P., Brix, A. E., Sells, D. M., Wyde, M. E., Orzech, D., Haseman, J. K., Flake, G., & Walker, N. J. (2004). Exocrine pancreatic pathology in female Harlan Sprague-Dawley rats after chronic treatment with 2,3,7,8-Tetrachlorodibenzo-p-dioxin and dioxin-like compounds. *Environmental Health Perspectives,* **112,** 903–909.

Ohtake, F, Baba, A., Takada, I., Okada, M., Iwasaki, K., Miki, H., Takahashi, S., Kouzmenko, A., Nohara, K., Chiba, T., Fujii-Kuriyama, Y., & Kato, S. (2007). Dioxin receptor is a ligand-dependent E3 ubiquitin ligase. *Nature,* **446,** 562-566.

Olsson, M. (1994). Effects of persistent organic pollutants on biota in the Baltic Sea. *Archives of Toxicology*, **16,** 43-52.

Olsson, M., Karlsson, B., & Ahnland, E. (1994). Diseases and environmental contaminants in seals from the Baltic and the Swedish west coast. *Science of the Total Environment,* **154,** 217-227.

Ortiz, R. M., & Worthy, G. A. J. (2000). Effects of capture on adrenal steroid and vasopressin concentrations in free-ranging bottlenose dolphins (*T. truncatus*). *Comparative Biochemistry and Physiology*, Part A, **125,** 317-324.

Pande, K., Moran, S. M., & Bradfield, C. A. (2005). Aspects of dioxin toxicity are mediated by Interleukin 1-Like Cytokines. *Molecular Pharmacology* **67**(5)**,** 1393-1398.

Ramirez, F., Fowell, D. J., Puklavec, M., Simmonds, S., & Mason, D. (1996). Glucocorticoids promote a Th2 cytokine response by CD41 T cells in vitro. *Journal of Immunology,* **156,** 2406-2410.

Reijnders, P. J. H., & de Ruiter-Dijkman, E. M. (1995). Toxicological and epidemiological significance of pollutants in marine mammals. In A. S. Blix, L. Walloe, & O. Ultang (Eds.), *Whales, seals, fish and man* (pp. 575-587). Tromsø: Elsevier Press.

Remillard, R. B. J., & Bunce, N. J. (2002). Linking Dioxins to Diabetes: Epidemiology and Biologic Plausibility. *Environmental Health Perspectives,* **110,** 853-858.

Ridgway, S. H., Carder, D. A., Kamolnick, T., Smith, R. R., Schlundt, C. E., & Elsberry, W. R. (2001). Hearing and whistling in the deep sea: Depth influences whistle spectra but does not attenuate hearing by white whales (*D. leucas*)) (Odontoceti, Cetacea). *Journal of Experimental Biology,* **204,** 3829-3841.

Rijnberk, A. (1996). Adrenals. In A. Rijnberk, (Ed.), *Clinical Endocrinology of dogs and cats* (pp. 61-94). London: Kluwer Academic Publishers.

Romero, L. M., & Butler, L. K. (2007). Endocrinology of stress. *International Journal of Comparative Psychology*, **this issue**, 89-95.

Romero, M. (2004). Physiological stress in ecology: Lessons from biomedical research. *Trends in Ecology & Evolution,* **19**(5)**,** 249-255.

Ruby, C. E., Funatake, C. J., & Kerkvliet, N. I. (2004). 2,3,7,8 Tetrachlorodibenzo-p-Dioxin (TCDD) Directly Enhances the Maturation and Apoptosis of Dendritic Cells In Vitro. *Journal of Immunotoxicology,* **1,** 159–166.

Ruby, C. E., Leid, M., & Kerkvliet, N. I. (2002). 2,3,7,8-Tetrachlorodibenzo-p-dioxin suppresses tumor necrosis Factor-α and Anti-CD40–Induced Activation of NF-κB/Rel in

dendritic cells: p50 Homodimer Activation is not affected. *Molecular Pharmacology,* **62**(3), 722-728.

St. Aubin, D. J. (2001). Endocrinology. In L.A. Dierauf & F.M.D. Gulland (Eds.), *Handbook of marine mammal medicine: Health, Disease and Rehabilitation*. Vol. 2 (pp. 165-192). Boca Raton, FL: CRC Press.

St. Aubin, D. J. (2002a). *Hematological and serum chemical constituents in pantropical spotted dolphins (S. attenuata) following chase and encirclement.* Report completed under contract 40JGNF200170 for the Southwest Fisheries Science Center National Marine Fisheries Service, NOAA. Administrative report LJ-02-37C. Retrieved July 27 2007 from: http://swfsc.noaa.gov/uploadedFiles/Divisions/PRD/Programs/ETP_Cetacean_Assessment/LJ_02_37C.pdf

St. Aubin, D. J. (2002b). *Further assessment of the potential for fishery-induced stress on dolphins in the Eastern Tropical Pacific.* Report completed under contract 40JGNF200170 for the Southwest Fisheries Science Center. National Marine Fisheries Service, NOAAA. Administrative report LJ-02-23C. Retrieved July 27, 2007 from: swfsc.noaa.gov/uploadedFiles/Divisions/PRD/Programs/ETP_Cetacean_Assessment/LJ_02_23C.pdf

St. Aubin, D. J., De Guise, S., Richard, P., Smith, T. G., & Geraci, J. R. (2001). Hematology and Plasma Chemistry as Indicators of Health and Ecological Status in Beluga Whales, *D. leucas. Arctic,* **54**(3)**,** 317–331.

St. Aubin, D. J., & Dierauf, L. A. (2001). Stress in Marine Mammals. In L.A. Dierauf & F.M.D. Gulland (Eds.), *Handbook of marine mammal medicine: Health, Disease and Rehabilitation*. Vol. 2 (pp. 253-269). Boca Raton, FL: CRC Press.

St. Aubin, D. J., Ridgway, S. H., Wells, R. S., & Rhinehart, H. (1996). Dolphin thyroid and adrenal hormones: Circulating levels in wild and semidomesticated *T. truncatus*, and influence of sex, age, and season. *Marine Mammal Science,* **12**(1)**,** 1-13.

Sapolsky, R. M., Romero, L. M., & Munck, A. U. (2000). How Do Glucocorticoids Influence Stress Responses? Integrating Permissive, Suppressive, Stimulatory, and Preparative Actions. *Endocrine Reviews,* **21**(1)**,** 55-89.

Savouret, J. F., Berdeaux, A., & Casper, R. F. (2003). The aryl hydrocarbon receptor and its xenobiotic ligands: A fundamental trigger for cardiovascular diseases. *Nutrition, Metabolism & Cardiovascular Diseases,* **13,** 104-113.

Schlundt, C. E., Finneran, J. J., Gardner, D. A., & Ridgway, S. H. (2000). Temporary shift in masked hearing thresholds of bottlenose dolphins, *T. truncatus*, and white whales, *D. leucas*, after exposure to intense tones. *Journal of the Acoustic Society of America,* **107,** 3496-3508.

Servant, M. J., Grandvaux, N., & Hiscott, J. (2002). Multiple signaling pathways leading to activation of interferon regulatory factor 3. *Biochemical Pharmacology*, **64,** 985-992.

Smoak, K. A., & Cidlowski, J. A. (2004). Mechanisms of glucocorticoid receptor signalling during inflammation. *Mechanisms of Ageing and Development,* **125,** 697–706.

Swaab, D. F, Bao, A.-M., & Lucassen, P. J. (2005). The stress system in the human brain in depression and neurodegeneration. *Ageing Research Reviews,* **4,** 141–194.

Swanson, H. I. (2002). DNA binding and protein interactions of the AHR/ARNT heterodimer that facilitate gene Activation. *Chemico-Biological Interactions,* **141,** 63–76

Taniguchi, T., Ogasawara, K., Takaoka, A., & Tanaka, N. (2001). IRF Family of transcription factors as regulators of host defense. *Annual Review of Immunology,* **19,** 623–655.

Tian, Y., Rabson, A. B., & Gallo, M. A. (2002). Ah receptor and NF-κB interactions: Mechanisms and physiological implications. *Chemico-Biological Interactions,* **141**, 97-115.

Troisi, G. M., Haraguchi, K., Simmonds, M. P., & Mason, C. F. (1998). Methyl sulphone metabolites of polychlorinated biphenyls (PCBs) in cetaceans from the Irish and the Aegean Seas. *Archives of Environmental Contamination & Toxicology,* **35,** 121-128.

Ulrich-Lai, Y.M., Figueiredo, H.F., Ostrander, M.M., Choi, D.C., Engeland, W.C., & Herman, J.P. (2006). Chronic stress induces adrenal hyperplasia and hypertrophy in a subregion-specific manner. *American Journal of Physiology. Endocrinology and Metabolism,* **291,** 965-973.

van Birgelen, A. P., Ross, D. G., DeVito, M. J., & Birnbaum, L. S. (1996). Interactive effects between 2,3,7,8-tetrachlorodibenzo-p-dioxin and 2,2',4,4',5,5'-hexachlorobiphenyl in female B6C3F1 mice: Tissue distribution and tissue-specific enzyme induction. *Fundamental & Applied Toxicology,* **34,** 118-131.

van Loveren, H., Ross, P. S., Osterhaus, A. D., & Vos, J. G. (2000). Contaminant-induced immunosuppression and mass mortalities among harbor seals. *Toxicology Letters,* **112-113,** 319-324.

Vogel, C. F. A., Nishimura, N., Sciullo, E., Wong, P., Li, W., & Matsumura, F. (2007a). Modulation of the chemokines KC and MCP-1 by 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in mice. *Archives of Biochemistry and Biophysics,* **461,** 169-175.

Vogel, C. F. A., Sciullo, E., & Matsumura, F. (2004). Activation of Inflammatory Mediators and Potential Role of Ah-Receptor Ligands in Foam Cell Formation. *Cardiovascular Toxicology,* **4,** 363-374.

Vogel, C. F. A., Sciullo, E., & Matsumura, F. (2007b). Involvement of RelB in aryl hydrocarbon receptor-mediated induction of chemokines. *Biochemical and Biophysical Research Communications* **363,** 722–726.

Wang, H., Faucette, S. R., Gilbert, D., Jolley, S.L., Sueyoshi, T., Negishi, M., & Lecluyse, E.L. (2003). Glucocorticoid receptor enhancement of pregnane X receptor-mediated CYP2B6 regulation in primary human hepatocytes. *Drug Metabolism & Disposition,* **31**(5), 620-630.

Williamson, M. A., Gasiewicz, T. A., & Opanashuk, L. A. (2005). Aryl Hydrocarbon Receptor Expression and Activity in Cerebellar Granule Neuroblasts: Implications for Development and Dioxin Neurotoxicity. *Toxicological Sciences,* **83,** 340-348.

Wright, A.J., Aguilar Soto, N., Baldwin, A.L., Bateson, M., Beale, C.M., Clark, C. et al. (2007b). Do Marine Mammals Experience Stress Related to Anthropogenic Noise? *International Journal of Comparative Psychology,* **this issue,** 274-316.

Zhao, X. Y., Malloy, P. J., Krishnan, A. V., Swami, S., Navone, N. M., Peehl, D. M., & Feldman, D. (2000). Glucocorticoids can promote androgen-independent growth of prostate cancer cells through a mutated androgen receptor. *Nature Medicine,* **6**, 703-706.

International Journal of Comparative Psychology, 2007, **20**, 217-227.
Copyright 2007 by the International Society for Comparative Psychology

Fishery Effects on Dolphins Targeted by Tuna Purse-seiners in the Eastern Tropical Pacific Ocean

Elizabeth F. Edwards
Southwest Fisheries Science Center, U.S.A.

Dolphins in the eastern tropical Pacific Ocean (ETP), particularly spotted (*Stenella attenuata*) and spinner (*Stenella longirostris*) dolphins, are subject to fishery-induced stress due to chase and encirclement by tuna purse-seiners intent on capturing the large yellowfin tuna that are frequently found associated with dolphin schools in this area of the Pacific Ocean. The direct, observed mortality of dolphins in the fishing nets has decreased over the years from several hundred thousand annually during the early 1960's when the fishing practice originated, to less than 5000 dolphins annually (thought to be a biologically insignificant level) since the early 1990s. Despite the decrease in observed mortality, the dolphin populations have not been recovering as expected. In an effort to determine whether fishery-related stress may be contributing to this lack of recovery, through unobserved effects on survival or reproduction, a variety of studies have been and continue to be conducted examining various aspects of interactions between ETP dolphins and the tuna purse-seine fishery. These studies include a review of current knowledge of stress physiology in mammals, a necropsy program to examine dolphins killed during purse-seining operations, a chase-recapture experiment, and various analyses of existing (historical) data which have led to ongoing studies of fishery effects on mother-calf pairs, ETP dolphin reproductive biology, and analyses of dolphin school composition. The effect of noise has not been addressed directly in these studies, but potentially contributes to fishery-related stress in terms of initiating the significant and prolonged evasion response typical of dolphin schools reacting to tuna purse-seiners in the ETP. Although studies completed to date have not provided a definitive answer to whether fishery-induced stress is a significant factor in the lack of dolphin stock recovery in the ETP, it is possible that at least some adults, and probably many young dolphins, are negatively affected by interactions with tuna purse-seine fishing operations.

Dolphins in the eastern tropical Pacific Ocean (ETP), particularly spotted (*Stenella attentuata*) and spinner (*Stenella longirostris*) dolphins, are frequently chased and encircled by tuna purse-seiners intent on capturing the large yellowfin tuna often found associated with dolphin schools in this area of the Pacific Ocean. The set procedure involves using helicopters to search for the disturbances caused by tuna schools feeding in association with dolphins and seabirds (National Research Council, 1992) or for bird flocks over the horizon. Once an associated tuna school has been located and determined large enough to invest the time and effort in capture, the seiner begins to set the net while 4-5 speedboats with large outboard engines are dropped off the back of the vessel to separate dolphins associated with tuna and chase them into the closing purse-seine. In an association unique to the eastern tropical Pacific Ocean (ETP), the tuna remain associated with the dolphins during the chase and capture, so that the closed and pursed seine then contains both the yellowfin tuna and the dolphins. Once the net is entirely closed

I thank Documentes Des Meers for the opportunity to present this work at the Noise Workshop, and the workshop participants and reviewers for numerous valuable discussions and comments. I also thank all the researchers whose work I have reviewed here, for their ongoing efforts to resolve the "tuna-dolphin problem in the ETP". Correspondence concerning this article should be addressed to Elizabeth F. Edwards, Southwest Fisheries Science Center NMFS, 8604 La Jolla Shores Drive, La Jolla, CA, 92037, U.S.A. (Elizabeth.Edwards@noaa.gov).

and pursed at the bottom, a specific maneuver by the vessel ("backdown") creates a long finger of small-mesh net (the "backdown channel") on the side of the seine opposite the vessel. Many dolphins have learned to expect this maneuver (Santurtun & Galindo, 2002) and gather near the appropriate area of the seine, waiting for the channel to form. The dolphins then escape over the submerged far end of the backdown channel and quickly leave the area (Chivers & Scott, 2002).

ETP dolphins respond to an impending set by beginning to flee as soon as the tuna seiner, the helicopter, or the speedboats are perceived (National Research Council, 1992). Because the initial response tends to occur several kilometers from the vessel (Au & Perryman, 1982; Hewett, 1985), initial perception appears to be acoustic rather than visual. The dolphins respond by moving closer together and increasing their swim speed from about 1-2 m/sec to 2-3 m/sec (Chivers & Scott, 2002; i.e., doubling to tripling their previous swim speed and thereby increasing their swimming power requirement by a factor of 8 to 27 times the power required for non-chase swim speeds (Edwards, 2006)).

The chase portion of the set typically lasts 30-40 minutes (with a small percentage of chases lasting up to about 80 minutes), encirclement lasts 30-60 minutes (with a very small percentage of encirclements lasting up to about 75 minutes), and length of confinement lasts another 40-60 minutes (with a small percentage lasting up to about 90 minutes) (Myrick & Perkins, 1995), so that time from initiation of chase to release typically ranges between about 1.5 and 2.5 hours (with a potential maximum in a few sets of about 4 hours). Once the dolphins perceive that the backdown channel is ready, they swim out quickly and continue their escape by swimming at even higher speeds (3-4 m/sec) for about 90 minutes before reverting to pre-chase behaviors (Chivers & Scott, 2002). Thus, each purse-seine set experience may disrupt normal ETP dolphin behavior for at least 30-40 minutes, if the dolphin manages to escape prior to capture, and for 3-4 hours (occasionally up to 5.5 hours) if the dolphin is captured in the seine and then released.

During the early 1960s, when the seining practice originated, several hundred thousand dolphins died in tuna purse-seine nets each year, reducing the populations spotted and spinner dolphins in the ETP by 70-80% (Wade, 1994). Improvements in fishing practices and introduction of individual vessel mortality limits, as well as apparent learning by the dolphins (currently, only about 4% of encircled dolphins need assistance leaving the net during backdown (Santurtun & Galindo, 2002)), have drastically reduced dolphin deaths in tuna nets, to less than 5000 dolphins annually (thought to be a biologically insignificant level) since the early 1990s (Inter-American Tropical Tuna Commission, 2004).

However, despite this dramatic decrease in purse-seine mortality, at least two stocks, northeastern offshore spotted and spinner dolphins, have not been recovering as expected (Gerrodette & Forcada, 2005). Because fishing effort on dolphins remains high (10,000-14,000 purse-seine sets per year (Inter-American Tropical Tuna Commission, 2004)), with each spotted dolphin being chased about 11 times and captured about 3 times per year, on average (Reilly et al., 2005), it is hypothesized that indirect effects of the fishery may adversely impact ETP dolphins. This potential for ongoing adverse fishery interactions has led to a

variety of research projects addressing the possibility that fishery effects (interactions) may be contributing to the lack of population recovery through unobserved effects on dolphin survival or reproduction.

Although the issue of adverse fishery effects (in addition to direct mortality) on ETP dolphins has been of concern since the early days of the fishery (e.g., Stuntz & Shay, 1979; Cowan & Walker, 1979; Coe & Stuntz, 1980) research through the early 1990's focused primarily on reducing directly-observed mortality in the purse-seines. Once the current low level of purse-seine mortality had been achieved, research focus turned to investigating other types of fishery effects.

A major series of research projects was initiated between 1997 and 2002, in accord with mandates of the International Dolphin Conservation Program Act (IDCPA), an amendment to the US Marine Mammal Protection Act (MMPA) (Reilly et al., 2005). IDCPA-mandated fishery effects studies focused on the question "is the fishery having a significant adverse impact on ETP dolphins?" and included four related projects broadly characterized as stress studies. These included 1) a review of current knowledge of stress physiology in mammals, with emphasis on marine mammal physiology, 2) a necropsy program to examine dolphins killed during purse-seining operations, 3) a chase-recapture experiment *in situ* using a chartered purse-seine vessel, and 4) various analyses of existing (historical) data (Reilly et al., 2005). The effect of related noise was not specifically investigated as a stressor in these studies, but contributes to fishery-related stress in terms of initiating the significant and prolonged evasion responses typical of dolphin schools chased and encircled by tuna purse-seiners in the ETP (Au & Perryman, 1982; Hewitt, 1985; Chivers & Scott, 2002). The IDCPA research program also included a suite of studies to estimate current abundances, monitor environmental associations and their potential effects, and assess status and trends of these dolphin populations. Results of those studies are not covered here.

This paper summarizes results from completed studies and presents status reports for ongoing and proposed studies addressing the question of whether fishery interactions may be negatively affecting population recovery of ETP dolphins.

Completed Studies

Research Prior to the IDCPA Program

Limited data were collected prior to the IDCPA program, although the potential for fishery-related stress was recognized early in the fishery, primarily based on observations of passive-sinking behaviors by dolphins in the purse-seine nets (Coe & Stunz, 1980). These unusual behaviors suggested the possibility of "capture myopathy" (a degenerative muscle condition which can lead to delayed death, thus creating unobserved fishery-related mortality; Stunz & Shay, 1979). Subsequent examination and sampling of *Longissimus dorsi* and hypaxial muscle from 65 dolphins killed in ETP tuna purse-seines found "no evidence of myopathy" (Cowan & Walker, 1979), but this sample size is too small to

definitively eliminate the possibility of capture myopathy affecting ETP dolphins at the population level. Another study suggested that examination of adrenal glands might provide a measure of fishery-related stress (Myrick & Perkins, 1995).

IDCPA Program Research

The stress literature review summarized current knowledge about the effects of physiological and behavioral stress in mammals, and related that information to potential effects on dolphins chased and encircled by tuna purse-seiners (Curry, 1999; St. Aubin, 2002a). The review concluded that tuna purse-seine fishing activities entail well-recognized stressors in other mammals, especially wild animals, including prolonged heavy exertion, social disturbance, and disruption of normal activities such as foraging. Typical mammalian responses to such disturbances include changes in metabolism, growth, reproduction, and immune status, any of which, alone or in combination, could significantly affect survival and reproduction. Of particular concern for ETP dolphins was the observation that prolonged heavy exertion in other wild mammals can lead to capture myopathy. Although specific response levels to specific stressors differ in detail between different mammals and environments, the review found that in general, the types of stressors presented by tuna purse-seine activities may affect dolphin survival, but quantitative estimates of the magnitude of these effects are not available (Curry, 1999; Reilly et al., 2005).

The necropsy study examined various physical characteristics of dolphins accidentally killed during tuna purse-seine operations. Due to logistic difficulties, only 56 dolphins were sampled during the 3-year study, far fewer than the desired minimum (for statistical power) of 300 dolphins per stock. However, although the small sample size precluded population-level conclusions, results provided revealing snapshots of physiological conditions and characteristics of dolphins killed in the nets. Various diseases unrelated to the fishery, but characteristic of normally healthy populations of wild mammals, were found in the majority of the dolphins (Cowan & Curry, 2002). Lymph nodes indicated normal, active lymphoid systems (Romano, Abella, Cowan, & Curry, 2002a). Heart, lungs and kidney contained lesions directly linked to death by asphyxiation, possibly resulting from an overwhelming alarm reaction leading to death by cardiac arrest (Cowan & Curry, 2002). Tissue abnormalities presenting as patchy fibrous scars in heart muscle and associated blood vessels may have formed previously in response to excess secretion of stress hormones, possibly indicating prior stress responses (e.g., possibly to fishery activity or predation attempts), although the direct cause and physiological consequences of the lesions could not be determined (Cowan & Curry, 2002). Opportunistic samples of skeletal muscle showed cell damage similar to that in heart muscle, indicative of a degree of capture myopathy that could lead to unobserved mortality in some cases (Reilly et al., 2005).

The Chase Encirclement Stress Study (CHESS) examined physiological and behavioral responses of ETP dolphins to repeated chase and encirclement (Forney, St. Aubin, & Chivers, 2002). During a two-month period, schools of spotted and mixed spotted/spinner dolphins were located, chased and encircled by

a chartered tuna purse-seine vessel using fishery-typical techniques (Forney et al., 2002). Individual dolphins were sampled, tagged and subsequently released with the rest of the captured dolphins. Radio-tagged focal dolphins were followed by a NOAA research vessel, and attempts were made over the following days to recapture the focal dolphin(s) and any associates. CHESS studies included analyses of blood parameters (standard veterinary blood panels, with particular focus on exertion-related enzymes and stress hormones), immune function, thermal condition, behavior, and reproductive parameters, with the intention of determining serial changes through time with repeated recaptures. Initial (first capture) samples were collected from several dozen dolphins, but recaptures were limited because tagged dolphins generally separated from their original school rather than remaining associated. Blood was obtained from 61 dolphins, 53 of which were assumed to be first captures; the remaining 8 samples were collected from dolphins recaptured 1-3 times. In general, these limited sample sizes precluded drawing population-level conclusions about effects of chase and capture. However, a number of important observations relevant to the basic objective were made, and these are summarized below.

Immune function was normal in all blood samples, with no notable abnormalities in the captured or recaptured dolphins (Romano, Keogh, & Danil, 2002b). Hormone and enzyme analyses provided strong evidence for activation of an acute stress response and muscle injury due to exertion (St. Aubin, 2002b). Samples from animals chased for 20-30 minutes exhibited mild muscle damage (consistent with lesions observed in the Necrospy Study samples) (St. Aubin, 2002b). Blood changes were not sufficient to cause life-threatening capture myopathy in any of the animals examined, but individuals differed greatly in overall stress response (St. Aubin, 2002b). Some dolphins showed much more dramatic elevations in hormones, enzymes, and other metabolic indicators, implying a wide variety of responses in the natural population (St. Aubin, 2002b).

The potential for heat stress, particularly in pregnant females required to maintain blood flow to the uterus, placenta and fetus regardless of body temperature, was evaluated by examining thermal photographs of skin surface temperatures after chases of more than 75 minutes (Pabst, McLellan, Meagher, & Westgate, 2002). Heat flux increased during chase for one of two tagged individuals, but core body temperatures were stable for all but one of 48 sampled dolphins, indicating that ETP dolphins are able to regulate body temperature despite elevated swim speeds during chase.

As observed in previous studies (e.g., Scott & Cattanach, 1998), dolphin school dynamics were highly fluid so that associations of individual dolphins were quite variable (Chivers & Scott, 2002). The passive-sinking behavior seen during the 1970s (Coe & Stunz, 1980) was not evident, although rafting behavior (vertical position with head out of the water) still occurred in some dolphins (0 to 8.5 % of the individuals in the net) at some times prior to backdown (Santurtun & Galindo, 2002). In 77% of sets, dolphins were observed circling outside the purse-seine, and overall, it was evident that ETP dolphins are now familiar with the purse-seine procedure and can anticipate backdown for release from the net (Santurtun & Galindo, 2002).

With extremely limited data, it was impossible to determine any effect of capture or recapture on reproduction. No fetal loss was observed, although there were modest decreases in levels of progesterone and testosterone in the two animals analyzed after successive recaptures (St. Aubin, 2002b). Nine females with relatively large calves were captured during at least one set. Three females originally captured with relatively large calves were recaptured with the same calf in subsequent sets, including one pair chased seven times and recaptured four times, and two pairs chased and captured twice. These recaptures indicate that larger calves are capable of remaining associated with their mothers during sets. However, developmental issues indicate that smaller calves (less than 1 year postpartum) may have more difficulty remaining associated with the mother during fishery activities (Noren, Biedenbach, & Edwards 2006; Noren & Edwards, 2007; Noren, Biedenbach, Redfern & Edwards 2007).

Historical biological data were examined in a number of ways, including: 1) to determine whether dolphin behavior differs relative to level of recent fishing effort (Mesnick, Archer, Allen, & Dizon, 2002); 2) to compare the demographic and reproductive parameters of spinner dolphins schools in 1988-1993 vs. 1998-2000 based on aerial photographs taken during NMFS research cruises (Cramer & Perryman, 2002); 3) to estimate the energetic cost to dolphins of purse-seine set evasion (Edwards, 2002); 4) as contributing data for a review of all available information on physiological and behavioral development in dolphin calves (Noren & Edwards, 2007); and 5) to compare the number of lactating females versus the number of nursing calves killed in the same sets (Archer, Gerrodette, Chivers, & Jackson, 2001; Archer, Gerrodette, Chivers, & Jackson, 2004). The results of the latter studies have led to the current focus on fishery effects on ETP dolphin mother-calf pairs and reproductive biology.

Mesnick, Archer, Allen, & Dizon (2002) found that spotted and spinner dolphins (the target species) exhibited more ship evasion and avoidance than did non-targeted dolphin stocks in areas with greater fishing effort. Chivers & Scott (2002) found that escape from tuna purse-seine sets involves prolonged and high-speed swimming (at least 90 minutes at 3-4 m/sec) in addition to the typical 60-100 minutes involved in chase and encirclement (Myrick & Perkins, 1995), bringing the total time of typical set involvement to 3-4 hours, including 2-3 hours of elevated swim speeds. Cramer & Perryman (2002) found that the proportion of calves in schools was not related to the species composition or number of conspecifics in the school, but was significantly lower in more recent years compared to earlier years. Edwards (2002) found that that additional energy costs of evading purse-seine sets are probably not important for adult ETP dolphins, but may present a significant burden to small nursing calves (and potentially their mothers). Archer et al. (2001) found far fewer calves than expected from the number of lactating females killed in tuna purse-seine nets, suggesting that at least some of the calves become separated from their mothers during tuna purse-seine sets in the ETP and that subsequent unobserved calf mortality is a potentially important issue. Noren & Edwards (2007) found that physical limitations of small dolphin calves coupled with behavioral independence of mothers may cause

mother-calf separation during tuna purse-seine set evasion, particularly with calves less than a year postpartum.

Despite limited sample sizes, IDCPA studies identified a number of fishery-related effects on ETP dolphins that could be contributing to stress-related injury and/or unobserved mortality (Reilly et al., 2005). These include 1) moderately elevated stress hormones (catecholemines) and enzymes in live-captured dolphins, indicative of muscle damage; 2) evidence of past (healed) muscle and heart damage in necropsy specimens (dolphins killed in the fishery), 3) fatal heart damage in virtually all necropsy specimens, possibly related to elevated catecholamines, 4) prolonged response to set activities, including post-release as well as during chase and capture, and 5) separation of mothers and calves. Although the effects observed in live-captured animals were all sub-lethal, differences in individual reactions to stressors could lead to more critical responses in some animals compared to others (St. Aubin, 2002b).

Research Subsequent to the IDCPA Program

Following discovery of the significant discrepancy between mortality of lactating females and nursing calves (Archer et al., 2001), additional research quantified the "calf deficit", determining that 75-95% of lactating females killed in tuna purse-seine sets are killed without an accompanying calf (Archer et al., 2004). Given the importance of the mother-calf bond to calf survival, and the potential for mating failure, fetal resorption or abortion in response to fishery activities, research subsequent to the IDCPA has focused on effects that fishery interactions may have on ETP dolphin mother-calf pairs, reproduction and calf survival.

Mother-calf research has focused on factors that can be expected to affect the proximity of mothers and calves during attempted evasion of purse-seine sets, with particular emphasis on the swimming behavior known as drafting in echelon position whereby the calf positions itself slightly above and behind the mother's midsection (Norris & Prescott, 1961). Mathematical and aerodynamic modeling of movement forces (Weihs, 2004; Weihs, Ringel, & Victor, 2006) and empirical kinematic analyses of swimming motions of bottlenose dolphin mothers and calves from birth through two years postpartum (Noren et al., 2006, Noren et al., 2007) both confirmed and quantified the significant hydrodynamic advantages (decreased cost of swimming and/or increased velocity) enjoyed by dolphin calves swimming in echelon, as well as the hydrodynamic disadvantages (decreased swim performance and increased swim effort) suffered by dolphin mothers (Noren, 2007). Mother dolphins swimming in echelon swim only about half as fast at mothers swimming independently (Noren, 2007), while 0-1 month calves in swimming echelon experience a 28% increase in average swim speed, 22% reduction in fluke stoke amplitude, and 19% increase in distance per stoke compared to calves swimming independently (Noren et al., 2007). Neonate dolphin calves can gain up to 90% of the thrust needed to move through the water alongside the mother at speeds up to 2.4 m/sec (Weihs, 2004), while mean and maximum swim speeds of 0-1 month old calves swimming independently were only 37% and 52% of adult speeds, with adult levels not achieved until at least one

year postpartum (Noren et al., 2006). Stroke amplitude and distance covered per stroke were also significantly lower than adult levels for independently swimming calves during the first year postpartum. Lower size-specific swim speed in 0-3 month olds compared to calves older than 10 months indicated that factors other than size (e.g., underdeveloped physiology) act synergistically with small body size to limit independent swim performance in dolphins during ontogeny (Noren et al., 2006). The modeling studies also revealed the importance of precise positioning for effective drafting, and included an observation of disrupted drafting when a neonate calf lost coordination during a respiratory leap attempted during escape-speed swimming in the ETP (Weihs, 2004). The importance of drafting for remaining associated with adults is illustrated by energetics modeling of swim speed duration capacity of independently-swimming (non-drafting) ETP spotted dolphins. Neonate spotted dolphins require 3.6 times more power per kilogram of muscle than an adult, to swim the same speed, and have a burst maximum speed of about 3 m/sec compared to an adult's 6 m/sec (Edwards, 2006). Even at two years of age, spotted dolphin calves must produce about 40% more power per kilogram of muscle than an adult to swim a given speed. Loss of the drafting advantage due to high-speed, fast maneuvering swimming during evasion of tuna purse-seine sets appears to be a significant and plausible source for the observed calf deficit.

Ongoing swimming kinematics research, not yet completed, includes estimation of the cost to mother dolphins of swimming with near-term pregnant morphology. Future modeling work should include estimation of the limits to drafting by dolphin calves in terms of speed and maneuvering during evasion of tuna purse-seine sets. Ongoing research on reproduction and survival includes development and application of methods to determine pregnancy rates of ETP dolphins from progesterone analyses of blubber biopsies taken *in situ*, and estimation of fetal mortality rates in ETP dolphins, based on biological samples collected during the 1980s from fishery-killed specimens.

Conclusion

In general, studies of fishery effects on ETP dolphin physiology, behavior, and population dynamics indicate that adult dolphins chased, encircled, and released during tuna purse-seine sets experience acute, intense stress during the event but most appear to recover from this experience, though some may develop long-term sequelae such as vascular and muscle lesions, reproductive failure, or reduced survival. Because even a relatively small fishery-induced decrease in reproduction or survival could lead to the observed failure of population recovery for ETP dolphins (e.g., Gerrodette & Forcada, 2005), it is possible that fishery effects on adults remain an important factor in the observed lack of population recovery The estimated calf deficit suggests that the purse-seine fishing procedure may be disrupting mother-calf associations in the ETP, and the studies of calf physiology, behavior, and swimming characteristics suggest that nursing calves not reunited with their mothers are not likely to survive. Incorporating age-based likelihoods of calf separation and subsequent mortality into population dynamics models that include age-specific fishery encounter rates is being investigated as a

tool to evaluate these potential effects of fishery activity on calf survival and subsequent population dynamics.

References

Archer, F., Gerrodette, T., Chivers, S., & Jackson, A. (2004). Annual estimates of the unobserved kill of pantropical spotted dolphin (*Stenella attenuata*) calves in the tuna purse-seine fishery in the eastern tropical Pacific. *Fishery Bulletin*, **102**(2), 233-244.

Archer, F., & Robertson, K. M. (2004). Age and length at weaning and development of diet of pantropical spotted dolphins, *Stenella attenuata*, from the eastern tropical Pacific. *Marine Mammal Science*, **20**(2), 232-245.

Archer, F., Gerrodette, T., Dizon, A., Abella, K., & Southern, S. (2001). Unobserved kill of nursing dolphin calves in a tuna purse-seine fishery. *Marine Mammal Science*, **17**, 540-554.

Au, D., & Perryman, W. (1982). Movement and speed of dolphin schools responding to an approaching ship. *Fishery Bulletin*, **80**(2), 371-379.

Chivers, S. J., & Scott, M. D. (2002). Tagging and tracking of *Stenella spp*. during the 2001 Chase Encirclement Stress Studies Cruise. *Administrative Report LJ-02-11*, NMFS, Southwest Fisheries Science Center, La Jolla, CA..

Coe, J. M., & Stuntz, W. (1980). Passive Behavior by the Spotted Dolphin, *Stenella attenuata*, in Tuna Purse Seine Nets. *Fishery Bulletin*, **78**(2), 535-537.

Cowan, D. F., & Curry, B. E. (2002). Histopathological assessment of dolphins necropsied onboard vessels in the eastern tropical Pacific tuna fishery. *Administrative Report LJ-02-24C*, NMFS, Southwest Fisheries Science Center, La Jolla, CA.

Cowan, D., & Walker, W. A. (1979). Disease Factors in *Stenella attenuata* and *Stenella longirostris* Taken in the Eastern Tropical Pacific Yellowfin Tuna Purse Seine Fishery. *Administrative Report LJ-79-32C*, NMFS, Southwest Fisheries Science Center, La Jolla, CA..

Cramer, K.., & Perryman, W. L. (2002). Estimation of reproductive and demographic parameters of the eastern spinner dolphin (*Stenella longirostris orientalis*) using aerial photography. *Administrative Report LJ-02-31*, NMFS, Southwest Fisheries Science Center, La Jolla, CA.

Curry, B. (1999). Stress in mammals: the potential influence of fishery-induced stress on dolphins in the eastern tropical Pacific Ocean. *NOAA-TM-NMFS-SWFSC-261*.

Edwards, E. F. (2006). Duration of unassisted swimming activity for spotted dolphin (*Stenella attenuata*) calves: Implications for mother-calf separation during tuna purse-seine sets. *Fishery Bulletin*, **104**, 125-135.

Edwards, E. F. (2002). Energetics consequences of chase by tuna purse-seiners for spotted dolphins (*Stenella attenuata*) in the eastern tropical Pacific Ocean. *Administrative Report LJ-02-29*, NMFS, Southwest Fisheries Science Center, La Jolla, CA.

Forney, K.A., St. Aubin, D. J., & Chivers, S. (2002). Chase Encirclement Stress Studies on dolphins involved in eastern tropical Pacific Ocean purse-seine operations during 2001. *Administrative Report LJ-02-32*, NMFS, Southwest Fisheries Science Center, La Jolla, CA.

Gerrodette, T., & Forcada, J. (2005). Non-recovery of two spotted and spinner dolphin populations in the eastern tropical Pacific Ocean. *Marine Ecology Progress Series*, **291**, 1-21.

Hewitt, R.P. (1985). Reaction of dolphins to a survey vessel: Effects on census data. *Fishery Bulletin,* **83**(2), 187-193.

Inter-American Tropical Tuna Commission. (2004). *Inter-American Tropical Tuna Commission Annual Report 2004.* Inter-American Tropical Tuna Commission, La Jolla, CA.

Mesnick, S.L., Archer, F., Allen, A. C., & Dizon, A. E. (2002). Evasive behavior of eastern Pacific dolphins relative to effort by the tuna purse-seine fishery. *Administrative Report LJ-02-30*, NMFS, Southwest Fisheries Science Center, La Jolla, CA 92037.

Myrick, A. C., & Perkins, P. C. (1995). Adrenocortical color darkness as indicators of continuous premortem stress in chased and purse-seined male dolphins. *Pathophysiology,* **2**, 91-204.

Noren, S. R. (2007). Infant Carrying Behaviour in Dolphins: Costly parental care in an aquatic environment. *Functional Ecology***, 22**, *284-288.*

Noren, S. R., Biedenbach, G., Redfern, J. V., & Edwards, E. F. (2007). Hitching a ride: The formation locomotion strategy of dolphin calves. *Functional Ecology,* **22**, *278-283.*

Noren, S. R., & Edwards, E. F. (2007). Physiological and behavioral development in delphinid calves: Implications for calf separation and mortality due to tuna purse-seine sets. *Marine Mammal Science,* **23**(1), 15-29.

Noren, S. R., Biedenbach, G., & Edwards, E. F. (2006). Ontogeny of swim performance and mechanics in bottlenose dolphins (*Tursiops truncatus). Journal of Experimental Biology,* **209**, 4724-4731.

Norris, K. S., & Prescott, J. S. (1961). Observations on Pacific Cetaceans of Californian and Mexican Waters. *University of California Publications in Zoology*, **63**, 291-402.

National Research Council. (1992). Dolphins and the tuna industry/Committee on reducing porpoise mortality from tuna fishing. *National Academy Press.* Washington, DC.

Pabst, D.A., McLellan, W. A., Meagher, E. M., & Westgate, A. J. (2002). Measuring temperatures and heat flux from dolphins in the eastern tropical Pacific: Is thermal stress associated with chase and capture in the ETP tuna purse-seine fishery? *Administrative Report LJ-02-34C*, NMFS, Southwest Fisheries Science Center, La Jolla, CA.

Romano, T., Abella, K., Cowan, D., & Curry, B. (2002a). Investigation of the morphology and autonomic innervation of the lymphoid organs in the pantropical spotted, spinner, and common dolphins (*Stenella attenuata, Stenella longirostris,* and *Delphinus delphis*) incidentally entangled and asphyxiated in the tuna purse-seine fishery in the eastern tropical Pacific. *Administrative Report LJ-02-25C*, NMFS, Southwest Fisheries Science Center, La Jolla, CA.

Romano, T., Keogh, M., & Danil, K. (2002b). Investigation of the effects of repeated chase and encirclement on the immune system of spotted dolphins (*Stenella attenuata*) in the eastern tropical Pacific. *Administrative Report LJ-02-35C*, NMFS, Southwest Fisheries Science Center, La Jolla, CA.

Reilly, S. B., Donahue, M. A., Gerrodette, T., Forney, K., Wade, P., Ballance, L., Forcada, J., Fiedler, P., Dizon, A., Perryman, W., Archer, F., & Edwards, E. F. (2005). Report of the Scientific Research Program under the International Dolphin Conservation Program Act. *NOAA Technical Memorandum* NMFS, NOAA-TM-NMFS-SWFSC-372.

Santurtun, E., & Galindo, F. (2002). Coping behaviors of spotted dolphins during fishing sets. *Administrative Report LJ-02-36C*, NMFS, Southwest Fisheries Science Center, La Jolla, CA.

Scott, M., & Catanach, K. (1998). Diel patterns in aggregations of pelagic dolphins and tunas in the eastern Pacific. *Marine Mammal Science*, **14**(3), 401-428.

St. Aubin, D. J. (2002a). Further assessment of the potential for fishery-induced stress on dolphins in the eastern tropical Pacific. *Administrative Report LJ-02-23C*, NMFS, Southwest Fisheries Science Center, La Jolla, CA.

St. Aubin, D. J. (2002b). Hematological and serum chemical constituents in pantropical spotted dolphins (*Stenella attenuata*) following chase and encirclement. *Administrative Report LJ-02-37C*, NMFS, Southwest Fisheries Science Center, La Jolla, CA.

Stuntz, W. L., & Shay, T. B. (1979). Report on Capture Stress Workshop. *Administrative Report LJ-79-28*, NMFS, Southwest Fisheries Science Center, La Jolla, CA.

Wade, P. R. (1994). Abundance and Population Dynamics of Two Eastern Pacific Dolphins, *Stenella attenuata* and *Stenella longirostris orientalis*. (Ph. D. Dissertation, University of California, San Diego) .

Weihs, D., Ringel, M., & Victor M. (2006). Aerodynamic Interactions Between Adjacent Slender Bodies. *AIAA Journal*, **44**(3), 481-484.

Weihs, D. (2004). The Hydrodynamics of Dolphin Drafting. *Journal of Biology*, **3**(2)**,** 801-815.

International Journal of Comparative Psychology, 2007, **20**, 228-236.
Copyright 2007 by the International Society for Comparative Psychology

The Long-term Consequences of Short-term Responses to Disturbance Experiences from Whalewatching Impact Assessment

David Lusseau
Dalhousie University, Canada
University of Aberdeen, United Kingdom

Lars Bejder
Murdoch University, Australia

Studies often use behavioral responses to detect the impact of given disturbances on animals. However, the observation of these short-term responses can often lead to contradicting results. Here we describe studies focusing on the impacts of whalewatching to show how the biological relevance of short-term responses can be inferred from contextual information. They showed that short-term behavioral responses could have long-term consequences for individuals and their populations using information about variation in response magnitude with exposure levels, long-term population biology data, and multiple response variables. They showed that the added energetic constraints of the responses can impair life functions and lead to influences on vital rates with the potential to affect population viability. Individuals will manage disturbances as another ecological variable and will assess its costs in relation to other energetic trade-offs associated with the occupancy of the habitat in which the disturbance takes place. This can lead to rapid shift in tactics to cope with the disturbance, such as shift from short-term avoidance tactics to long-term habitat abandonment. When individuals cannot elude proximity to the disturbance, their fitness is reduced as observed through reduced reproductive success. These studies provide mechanisms to inform the US National Research Councils' Population Consequences of Acoustic Disturbance framework in which the influence of noise impact of on marine mammal conservation can be studied.

Many studies are now highlighting that what we perceive as short-term responses to disturbances can have unforeseen consequences for the life history of individuals exposed to those disturbances and the dynamics of their populations (Coltman et al., 2003; Cooke & Schramm, 2007; Lusseau, Lusseau, Bejder & Williams, 2006a; Proaktor, Coulson, & Milner-Gulland, 2007). These consequences can occur at an ecological scale with for example added energetic constraints from the responses influencing the homeostasis of individuals. They can also occur at an evolutionary scale. For example, selective harvesting can influence the genetic make-up of populations by selectively removing individuals with similar traits that are highly heritable (Coltman et al., 2003). These impacts influence the viability of populations, either by decreasing their fitness or by decoupling the populations from the environment in which they evolve because disturbances become a driving force for the life history of individuals at either of the temporal scales.

LB was funded by the Western Australian Department of Conservation and Land Management, Danish Research Agency, PADI Foundation, Patrick Lett Fund, Dalhousie University Faculty of Graduate Studies. DL was funded by Killam trusts. Fiordland studies were funded by the New Zealand Department of Conservation and the New Zealand Whale and Dolphin Trust. Funding for the Doubtful Sound bottlenose dolphin population biology study was provided by the University of Otago and the New Zealand Whale and Dolphin Trust. Correspondence concerning this article should be addressed to David Lusseau, University of Aberdeen, School of Biological Sciences, Zoology Bldg, Tillydrone Avenue, Aberdeen, AB24 2TZ, U.K. (d.lusseau@abdn.ac.uk).

In excess of 700 to 1000 cetacean populations routinely interact with tour boats (Hoyt, 2001). The potential impact of interactions between cetaceans and tourist vessels has been studied for more than 20 years (Baker & Herman, 1989; Corkeron, 2004). Over this period a wide variety of short-term effects has been detected on many species (Au & Green, 2000; Bejder, Dawson, & Harraway, 1999; Blane & Jaakson, 1995; Hastie, Wilson, Tufft & Thompson, 2003; Lusseau, 2006; Nowacek, Wells, & Solow, 2001; Williams, Trites, & Bain, 2002). These include changes in respiration patterns, variation in path directedness and other short-term behavioral alterations resulting from apparent horizontal and vertical avoidance tactics (Frid & Dill, 2002). However, it has been difficult to move from the description of short-term changes, which sometime appeared contradictory, to a more comprehensive understanding of the biological relevance of these impacts (Corkeron, 2004). Indeed interpreting behavioral responses outside the biological and ecological context in which they are studied has been shown to be uninformative (Beale & Monaghan, 2004; Bejder, Samuels, Whitehead & Gales, 2006a; Gill, Norris, & Sutherland, 2001).

Recent studies show that these short-term avoidance tactics can lead to biologically significant effects which can have long-term consequences for individuals and their populations (Bejder, 2005; Bejder et al., 2006a; Bejder et al., 2006b; Foote, Osborne, & Hoelzel, 2004; Lusseau, 2005; Lusseau, Slooten, & Currey, 2006b; Williams, Lusseau, & Hammond, 2006). These latter studies have taken a multi-contextual approach to elucidate the mechanisms linking short-term avoidance tactics to long-term impacts. Using comparisons between control and impact sites and long-term life history data they have revealed how whalewatching disturbance, a chronic intermittent stressor, had short-term effects on the lives of cetaceans which lead to long-term consequences for the viability and fitness of individuals and their populations. Whalewatching refers here to interactions between vessels and both dolphins and whales. Here we use three examples to highlight these mechanisms. We argue that this work is paving our understanding of principles governing the impacts of human activities on cetaceans. In particular, research in the effects of whalewatching can contribute significantly to a better understanding of the transfer functions in the Population Consequences of Acoustic Disturbance (PCAD) model (National Research Council, 2005).

Methods

We undertook studies on bottlenose dolphins (*Tursiops* sp.) at two sites: Shark Bay, Australia (Bejder et al., 2006a) and Fiordland, New Zealand (Lusseau, 2004). We will also present work carried out in collaboration with other authors on killer whales (*Orcinus orca*) off Vancouver Island, Canada (Williams et al., 2006). In Shark Bay, immediate responses to controlled vessel approaches were evaluated at both control and impact sites, depending on whether whalewatching occurred at those sites or not. Observed effects were related to long-term dolphin photo-identification records, reproductive rates and cumulative exposure measures to vessels (Bejder, 2005; Bejder et al., 2006a; Bejder et al., 2006b). In a similar fashion, we measured immediate behavioral responses of individuals and schools of bottlenose dolphins to boat interactions in Fiordland in two populations that were exposed to different levels of boat interactions. These two populations, one residing in Doubtful Sound and another whose home range centers on Milford Sound, are exposed to similar ecological conditions but are distinct. We then related these responses to long-term habitat use and reproductive success in relation with the rate of exposure to these disturbances (Lusseau, 2003a; Lusseau, 2003b; Lusseau, 2004, 2005; Lusseau et al., 2006a; Lusseau et al., 2006b). The Fiordland study also benefited from a natural experiment in that we made predictions regarding the consequences of increased tourism

levels in Doubtful Sound following the results of the study (2000-2002) that were tested after tourism intensity did increase in subsequent years (2003-2007).

Results

Shark Bay, Australia

In Shark Bay, dolphin abundance was compared within adjacent tourism and control sites, over three consecutive 4.5-year periods wherein tourism levels increased from zero (1988-1993), to one (1993-1998), to two (1998-2003) dolphin-watching operators. As the number of tour operators increased from one to two, there was a significant average decline in dolphin abundance (14.9%; 95% CI = -20.8 to -8.23), approximating a decline of one per seven individuals in the tourism site. In contrast, abundance in the adjacent control site, which was not used by tour boats, did not change significantly (Bejder et al., 2006b).

Additionally, the behavioral response of dolphins to experimentally controlled boat interactions was quantified at two sites: the impact site mentioned above, and another control site, located 17km away from the impact site, that had similar ecological features. The movement of dolphins became more erratic during interactions and dolphin schools tightened. However, the effect size was smaller at the impact site (Bejder et al., 2006a), which traditionally would have been explained as a sign of "habituation". However, in the light of the abundance study, it is more parsimonious to infer that individuals left at the impact site could afford to respond as much as others at the control site, because of reduced fitness. Indeed, the reproductive success of females in this area was linked to their cumulative exposure to boat interactions (Bejder, 2005).

Fiordland, New Zealand

The Milford Sound population was exposed to approximately seven times more tourism traffic than the Doubtful Sound population (Lusseau, 2004). Interactions affected behavioral budget in a similar fashion in both fiords leading to significant increased time spent travelling and decreased time spent resting (Lusseau, 2003a, 2004). They also increased the duration of travelling bouts, leading to added energetic challenges for individuals with less relative energetic stores (i.e., females and especially females with calves or pregnant). These added costs were apparent in that females tended to have different avoidance strategies than males, undergoing vertical avoidance strategies only when the boat interaction intrusiveness was such that it was highly likely to lead to injuries to non-avoiding individuals (Lusseau, 2003b).

While tourism exposure was much higher in Milford Sound than Doubtful Sound, the time spent interacting with boats in both fiords was similar (Lusseau 2004). This was linked to an avoidance of Milford Sound by dolphins during seasons with high tourism traffic (boat traffic was the only oceanographic predictor of residency pattern: $r = -0.814$, $p = 0.021$, Lusseau, 2005). In addition, when dolphins visited the fiord they avoided location with high boat traffic at peak traffic hours ($r = -0.888$, $p = 0.0018$, Lusseau, 2005). There was a linear relationship between boat traffic and dolphin-boat interaction pattern until the average time elapsed between two interactions reached 68 minutes (Lusseau, 2004; Lusseau et al., 2006b). Beyond this point,

dolphins switched from a short-term behavioral avoidance strategy to long-term avoidance strategy (habitat displacement) because the former strategy was no longer beneficial (Lusseau, 2004). Tourism activities affect only a portion of the home range of the Milford Sound population. Therefore, habitat displacement is a possible tactics for the individuals to manage the impacts. In contrast, tourism activities are pervasive throughout the home range of the Doubtful Sound population. We predicted that if boat interactions were to intensify and pass the 68-minute threshold, the population could only cope by decreasing its reproductive success (Lusseau et al., 2006b). Once boat traffic increased beyond the 68-minute threshold, the population suffered a dramatic decline in abundance (Currey, Dawson, & Slooten, in press; Lusseau et al., 2006b), passing from 67 to 56 individuals in a very short period. There was also a drastic significant decline in reproductive success with an increase in neonatal/stillbirth deaths (1994-1999: stillbirth presence: 2/5 years, stillbirth rate: 0.13 stillbirth/year; 2000-2007: 6/7 years, 0.34 stillbirth/year; randomization tests respectively: $p=0.044$ and $p=0.043$ (Lusseau et al., 2006b) and overall calf survival rate (Currey et al., submitted). This decline in calf survival could explain solely the population decline (Currey et al., submitted).

Vancouver Island, Canada

This study showed that boat traffic was also significantly affecting the behavioral budget of northern resident killer whales (Williams et al., 2006). They reduced foraging opportunities and increased travelling time. However, a simple bioenergetic model showed that while the behavioral effect size was greater for travelling than for foraging, the loss in foraging opportunity was leading to a greater energetic cost, by decreasing energy intake by 18%. In contrast, the added energetic cost of increased activities was only leading to a 3 to 4% increase in energy output for individuals (Williams et al., 2006). This showed that the biologically significant impact of boat interactions principally focused on food intake for this population. Such studies can help us prioritize management actions to minimize the biological significance of the impact. In this example, preventing boat interactions while whales are foraging will have a disproportionately greater influence on the overall impact of whalewatching than other restrictions would. Therefore establishing no-boat zones around foraging hotspots would be an ecologically and economically sensible measure (Lusseau & Higham, 2004).

Discussion

Results presented here indicate biologically significant impacts of an apparently benign human activity, i.e., watching whales and dolphins. The success of detecting population level effects was based on long-term population monitoring and the availability of information on the variation in vessel exposure between individuals, sites, and populations. The influence of these impacts on population viability can be inferred using the dose response relationships these studies describe. Early individual-based models show that these impacts are highly likely to endanger the viability of small populations which have restricted immigration/emigration because of the increased cumulative exposure they incur (Lusseau et al., 2006a).

The consequences of energetic challenges

The published studies we present here show that increased energetic challenges, either as added travelling costs or reduced foraging opportunities, can lead to reduced fitness for individuals. If such challenges occur too often, individuals shift into long-term avoidance strategies when possible by avoiding the degraded areas. However, such long-term decisions have to be balanced with other costs and benefits to leave a habitat degraded by whalewatching or leave a school exposed to whalewatching. These trade-offs lead to non-linear relationships with a rapid shift into long-term strategies when short-term tactics are no longer beneficial. This highlights that these behavioral systems, like other complex systems, can be shifted from one basin of attraction to another quite rapidly (van Nes & Scheffer, 2007). Individuals that cannot leave degraded habitat have reduced fitness leading to, at least, reduced reproductive success. This shows that at the population-level these shifts in basin of attraction may not always lead to evolutionary stable solutions.

Modeling population-level consequences

This described link between whalewatching disturbance exposure and reproductive success and survival probability can be used in agent-based simulations to define the likelihood that these effects can endanger the viability of exposed cetacean populations (Lusseau et al., 2006a). More importantly, the uncertainty surrounding the estimated dose-response curves can be incorporated in these models, so that its influence on the likelihood populations will remain viable can be accounted (Lusseau et al., 2006a). Agent-based simulations provide a tool to disturb artificial individuals in a population in a realistic manner because the rules of interactions (timing, duration, number of interactions, temporal variation) can be informed by empirical data. Unsurprisingly, these models illustrate how small populations, with restricted immigration and/or emigration, are less likely to survive even low levels of whalewatching exposure (Lusseau et al., 2006a). That is because such features increase the cumulative exposure to disturbance per capita. In addition, once the population starts to decline, restricted immigration means that exposure per individual intensifies, precipitating the population in an extinction vortex (Lusseau et al., 2006a).

Insights for the PCAD model

These studies provide templates to inform the PCAD model (Figure 1). The highlighted studies bring valuable insight into the three transition functions of the PCAD model. They show that repetitive short-term behavioral change can influence life functions by imposing additional costs to the energetic budget of individuals. The resulting impact on individuals will vary with the life history of the targeted species. In some instances, decreased energy intakes will predominantly drive the impact of the responses, while in others it may be the added energetic cost of transport.

Impacts on life functions can affect vital rates. These studies show that the influence of these changes on vital rates is non-linear, their impact shifting abruptly around a threshold. At this stage, whalewatching studies only provide a mechanistic function in an energetic framework. Other life functions may be

impaired, such as socializing, and those impacts can also have influences on vital rates, such as reproduction rate. Much work is needed to understand the principles governing these mechanisms that will be highly species-specific.

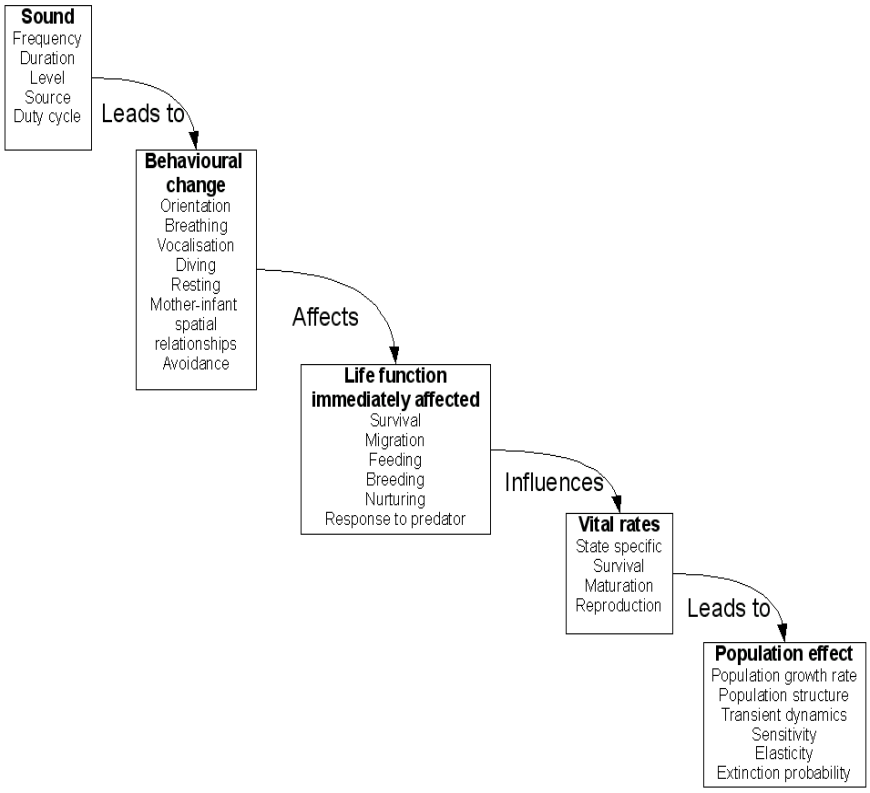


Figure 1. Modeling population-level consequences. Printed as modified from the Population Consequences of Acoustic Disturbance model developed by the US National Research Councils (National Research Council, 2005) with permission from the National Academies Press, Copyright 2005, National Academy of Sciences.

Finally, as it has been shown in the case of other anthropogenic impacts (Slooten, Fletcher, & Taylor, 2000), the alteration of vital rates can lead to influences on the viability of populations. This will depend on the resilience of the population's carrying capacity and therefore small, closed population are highly likely to be more prone to extinction under these scenarios.

Conclusion

We have shown here that there is high propensity for individuals to have context-specific responses to disturbances. It is also expected that human activities will have disproportionate influences on different individuals depending on their current fitness and life history strategy (Lusseau, 2003b; Munch & Conover, 2003; Perez-Tris, Diaz, & Telleria, 2004). If the impacts of these activities are significant enough to select against sensitive individuals, these disturbances may also influence the evolutionary dynamics of populations since the predisposition for risk-taking behavior may be heritable

in many species (Brick & Jakobsson, 2002; van Oers, Drent,, de Goede, & van Noordwijk, 2004). This population-level adaptation could result in lower observed effect size of disturbance. Such variation can be interpreted as the population "habituating" to the disturbance when in fact the population is reacting to this disturbance in several dimensions. This conclusion highlights the need for contextual information to define the biological relevance of observed short-term effects and the danger of interpreting these effects out of context.

References

Au, W. L., & Green, M. (2000). Acoustic interaction of humpback whales and whale-watching boats. *Marine Environmental Research*, **49**(5), 469-481.

Baker, C. S., & Herman, L. M. (1989). *Behavioral responses of summering humpback whales to vessel traffic: experimental and opportunistic observations*. Anchorage, Alaska: National Park Service NPS-NR-TRS-89-01.

Beale, C. M., & Monaghan, P. (2004). Behavioural responses to human disturbance: A matter of choice? *Animal Behaviour*, **68**, 1065-1069.

Bejder, L. (2005). *Linking short and long-term effects of nature-based tourism on cetaceans.* Unpublished PhD, Dalhousie University, Halifax.

Bejder, L., Dawson, S. M., & Harraway, J. A. (1999). Responses by Hector's dolphins to boats and swimmers in Porpoise Bay, New Zealand. *Marine Mammal Science*, **15**(3), 738-750.

Bejder, L., Samuels, A., Whitehead, H., & Gales, N. (2006a). Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. *Animal Behaviour*, **72**, 1149-1158.

Bejder, L., Samuels, A., Whitehead, H., Gales, N., Mann, J., Connor, R. C., Heithaus, M. R., Watson-Capps, J., Flaherty, C., & Krutzen, M. (2006b). Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology*, **20**(6), 1791-1798.

Blane, J. M., & Jaakson, R. (1995). The impact of ecotourism boats on the Saint Lawrence beluga whales. *Environmental Conservation*, **21**(3), 267-269.

Brick, O., & Jakobsson, S. (2002). Individual variation in risk taking: the effect of a predatory threat on fighting behavior in Nannacara anomala. *Behavioral Ecology*, **13**(4), 439-442.

Coltman, D. W., O'Donoghue, P., Jorgenson, J. T., Hogg, J. T., Strobeck, C., & Festa-Bianchet, M. (2003). Undesirable evolutionary consequences of trophy hunting. *Nature*, **426**(6967), 655-658.

Cooke, S. J., & Schramm, H. L. (2007). Catch-and-release science and its application to conservation and management of recreational fisheries. *Fisheries Management and Ecology*, **14**, 73-79.

Corkeron, P. J. (2004). Whalewatching, iconography, and marine conservation. *Conservation Biology*, **18**(3), 847-849.

Currey, R. J. C., Dawson, S. M., & Slooten, E. (in press). New abundance estimates suggest Doubtful Sound bottlenose dolphins are declining. *Pacific Conservation Biology*.

Currey, R. J. C., Dawson, S. M., Slooten, E., Lusseau, D., Schneider, K., Haase, P., Boisseau, O. J., & Williams, J. A. (submitted). Identifying the demographic source of a population decline: Survival rates and risk assessment for bottlenose dolphins in Doubtful Sound. *Biological Conservation*.

Foote, A. D., Osborne, R. W., & Hoelzel, A. R. (2004). Whale call response to masking boat noise. *Nature*, **428**, 910.

Frid, A., & Dill, L. M. (2002). Human-caused disturbance stimuli as a form of predation risk. *Conservation Ecology*, **6**(1), 11.

Gill, J. A., Norris, K., & Sutherland, W. J. (2001). Why behavioural responses may not reflect the population consequences of human disturbance. *Biological Conservation,* **97**(2), 265-268.

Hastie, G. D., Wilson, B., Tufft, L. H., & Thompson, P. M. (2003). Bottlenose dolphins increase breathing synchrony in response to boat traffic. *Marine Mammal Science,* **19**(1), 74-84.

Hoyt, E. (2001). *Whale watching 2001*. London: International Fund for Animal Welfare.

Lusseau, D. (2003a). Effects of tour boats on the behavior of bottlenose dolphins: Using Markov chains to model anthropogenic impacts. *Conservation Biology,* **17**(6), 1785-1793.

Lusseau, D. (2003b). Male and female bottlenose dolphins *Tursiops* sp. have different strategies to avoid interactions with tour boats in Doubtful Sound, New Zealand. *Marine Ecology-Progress Series,* **257**, 267-274.

Lusseau, D. (2004). The hidden cost of tourism: Detecting long-term effects of tourism using behavioral information. *Ecology and Society,* **9**(1), 2.

Lusseau, D. (2005). The residency pattern of bottlenose dolphins (*Tursiops* spp.) in Milford Sound, New Zealand, is related to boat traffic. *Marine Ecology Progress Series,* **295**, 265-272.

Lusseau, D. (2006). The short-term behavioral reactions of bottlenose dolphins to interactions with boats in Doubtful Sound, New Zealand. *Marine Mammal Science,* **22**(4), 802-818.

Lusseau, D., & Higham, J. E. S. (2004). Managing the impacts of dolphin-based tourism through the definition of critical habitats: The case of bottlenose dolphins (Tursiops spp.) in Doubtful Sound, New Zealand. *Tourism Management,* **25**, 657-667.

Lusseau, D., Lusseau, S. M., Bejder, L., & Williams, R. (2006a). *An individual-based model to infer the impact of whalewatching on cetacean population dynamics.* St Kitts: International Whaling Commission SC/58/WW7.

Lusseau, D., Slooten, E., & Currey, R. J. C. (2006b). Unsustainable dolphin-watching tourism in Fiordland, New Zealand. *Tourism in Marine Environments,* **3**(2), 173-178.

Munch, S. B., & Conover, D. O. (2003). Rapid growth results in increased susceptibility to predation in Menidia menidia. *Evolution,* **57**(9), 2119-2127.

National Research Council. (2005). *Marine mammal populations and ocean noise: Determining when noise causes biologically significant effects*. Washington, DC: US National Academy of Sciences.

Nowacek, S. M., Wells, R. S., & Solow, A. R. (2001). Short-term effects of boat traffic on bottlenose dolphins, Tursiops truncatus, in Sarasota Bay, Florida. *Marine Mammal Science,* **17**(4), 673-688.

Perez-Tris, J., Diaz, J. A., & Telleria, J. L. (2004). Loss of body mass under predation risk: Cost of antipredatory behaviour or adaptive fit-for-escape? *Animal Behaviour,* **67**, 511-521.

Proaktor, G., Coulson, T., & Milner-Gulland, E. J. (2007). Evolutionary responses to harvesting in ungulates. *Journal of Animal Ecology,* **76**(4), 669-678.

Slooten, E., Fletcher, D., & Taylor, B. L. (2000). Accounting for uncertainty in risk assessment: Case study of Hector's dolphin mortality due to gillnet entanglement. *Conservation Biology,* **14**(5), 1264-1270.

van Nes, E. H., & Scheffer, M. (2007). Slow recovery from perturbations as a generic indicator of a nearby catastrophic shift. *American Naturalist,* **169**(6).

van Oers, K., Drent, P. J., de Goede, P., & van Noordwijk, A. J. (2004). Realized heritability and repeatability of risk-taking behaviour in relation to avian personalities. *Proceedings of the Royal Society of London Series B-Biological Sciences,* **271**(1534), 65-73.

Williams, R., Lusseau, D., & Hammond, P. S. (2006). Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca*). *Biological Conservation*, **133**(3), 301-311.

Williams, R., Trites, A. W., & Bain, D. E. (2002). Behavioural responses of killer whales (*Orcinus orca*) to whale-watching boats: Opportunistic observations and experimental approaches. *Journal of Zoology*, **256**, 255-270.

International Journal of Comparative Psychology, 2007, **20**, 237-249.
Copyright 2007 by the International Society for Comparative Psychology

Adaptive Management, Population Modeling and Uncertainty Analysis for Assessing the Impacts of Noise on Cetacean Populations

Brendan A. Wintle
University of Melbourne, Australia

Population modeling is now widely used in threatened species management and for predicting the impacts and benefits of competing management options. However, some argue that the results of models must be used with caution, particularly when data are limited. This is important, as even the simplest models would generally require more data (and knowledge) than are available in order to have complete confidence in model predictions. In particular, population models often suffer from a lack of data on demographic rates, spatial distribution, dispersal, management responses, habitat correlations and the magnitude of temporal variations. A number of authors identify behavioral and physiological responses of animals to anthropogenic noise. Assessing population level impacts of noise on cetacean populations is essential to understanding how noise impacts on the future viability of marine mammal populations. This assessment will be particularly challenging due to the difficulties associated with identifying a clear link between behavioral responses of animals and physiological impacts, observing and measuring changes in cetacean population parameters and the long lag-times over which population changes manifest in long-lived species. The urgency of the conservation situation for many of these socially important species demands immediate action, despite pervasive uncertainty. Adaptive management provides a coherent framework for action and continuous improvement under uncertainty. I review the elements of adaptive management and discuss the role of population modeling in that context. I discuss Bayesian approaches to enhancing inferential power and reducing uncertainty in model parameter estimation. I then review approaches to characterizing irreducible uncertainty with Monte Carlo methods and sensitivity analysis and conclude with a brief discussion of formal decision tools available to assist with decision making under severe uncertainty. I propose that urgently needed action should not be postponed due to uncertainty and that adaptive management provides a coherent framework for instituting immediate action with a plan for learning.

Of primary interest to conservation practitioners is the degree to which human activities (such as anthropogenic noise) induce physiological and behavioral responses (e.g., a prolonged stress response) that ultimately manifest in changes to population dynamics such as reduced yearly survival and fecundity (collectively referred to as *vital rates*), and metapopulation dynamics such as immigration and emigration rates. More specifically, it is possible that anthropogenic noise may impact on marine mammal populations through direct physiological impacts leading to reduce survivorship and fecundity, or indirectly through changed behavior such as interrupted or altered foraging, mating or migration patterns (see Bateson, this issue; Beale, this issue; Deak, this issue; Lusseau, this issue; Romero & Butler, this issue; Wright et al., this issue, a. There

I thank Andrew Wright for motivating this work and providing substantial input. This work arose from the Workshop on Noise-Related Stress in Marine Mammals hosted and funded by Dieter Paulmann through the Dokumente des Meeres organization. The manuscript was substantially improved by comments from Igor Linkov and Scott Ferson. Correspondence concerning this article should be addressed to Brendan Wintle, University of Melbourne, Australia. (brendanw@unimelb.edu.au).

is mounting evidence that anthropogenic noise will result in population level impacts on marine mammal species, but substantial uncertainty about exactly how anthropogenic noise impacts will manifest. This is a common situation in conservation and natural resource management. In most situations we lack information about the magnitude of anthropogenic impacts and the efficacy of ameliorative actions on vital rates and metapopulation dynamics, as well as how they interact with environmental influences. Data on 'natural' demographic rates are also often lacking making inference about the population-level impacts of noise particularly challenging.

While such uncertainties are pervasive in conservation science, attempts at dealing with uncertainties in decision making have been largely ad-hoc and few applications utilize formal decision theory. However, some principles of decision making under uncertainty are articulated in the literature (Holling, 1978; Walters, 1986; Walters & Holling, 1990) and coherent approaches to management and decision making under uncertainty have recently emerged (Dorazio & Johnson, 2003; Nichols & Williams, 2006). Bayesian approaches to dealing with uncertainty due to imperfect knowledge and data have long been available but are only now becoming more widely used by ecologists and conservation biologists (Dorazio & Johnson, 2003; Ellison, 2004; McCarthy, 2007). There are a rising number of practical examples of formal decision making in conservation and natural resource management (Gerber et al., 2005; Hauser, Pople, & Possingham, 2006; Johnson & Williams, 1999; McCarthy & Possingham, 2007; Moilanen & Wintle, 2006; Regan et al., 2005), and the number of people trained to implement formal decision techniques is increasing. The synthesis of adaptive management principles, Bayesian approaches to characterizing and reducing uncertainty, and formal decision protocols may provide the basis for improved transparency, efficiency and robustness of conservation management under uncertainty. However, there are few examples of the successful integration of these approaches in practical applications of adaptive conservation management. Here I review aspects of uncertainty analysis and experimental management of threatened species populations and propose a framework for learning about the population-level impacts of noise-related stress effects.

Management under uncertainty: The adaptive management framework

Because uncertainty is pervasive in conservation management it is not appropriate to use uncertainty as an excuse for inaction (Bruntland, 1987), as inaction often results in deleterious environmental and biodiversity outcomes (Stern, 2007). Postponing decisions and changes to management because evidence for environmental harm is inconclusive or because impacts are not yet perfectly measured may be a highly sub-optimal strategy for conservation and should be weighed against the costs and benefits of various alternative actions. Adaptive management has been proposed as a paradigm for management under uncertainty and continuous improvement (Johnson et al., 1997; Linkov, Satterstrom, Kiker & Bridges, 2006a; Walters, 1986; Walters & Holling, 1990). Adaptive management can be loosely defined as management with a plan for learning. Under adaptive

management a range of management actions are prescribed at each time step that have the dual purpose of achieving management goals and facilitating learning about the system under management and the relative performance of management strategies. Adaptive management may be described in four steps (Figure 1);

i) identification of management goals, constraints and performance measures;
ii) specification of management options;
iii) identification of competing system models and model weights; and
iv) allocation of resources, implementation of management actions and monitoring of management performance.

The integration of 'implementation of management actions' and 'monitoring' emphasizes that monitoring is central to management and not an optional extra.

Modern interpretations of adaptive management based on adaptive optimization encourage an iterative approach to decision making (also known as 'state-based' decision making; Nichols & Williams, 2006). The act of determining management actions (strategies) for a discrete period of time that are optimal with respect to one's belief and uncertainty about the state of the system, as well as one's predictions about how the system will respond to management is intuitive though not always simple to achieve (see Allan and Curtis, 2005; Stankey et al., 2003, 2005). Indeed, it is not necessary that managers adopt formal optimization methods when implementing adaptive management as long as there is a plan for learning and a willingness to adapt management decisions in light of evidence that is collected through management experiments. Adaptive management is appealing in that it explicitly acknowledges that the decision being made is subject to substantial uncertainty and may change in the next time step depending on what is discovered (learnt) in the intervening period. It doesn't require the completion of an experiment before a change to management can be instituted; rather it identifies the best decision to be taken now, based on what is believed about the state of the system and what has been discovered to date through previous monitoring and research. Adaptive management is well suited for managing systems in which changes take a long time to become apparent and definitive experiments are not possible in reasonable timeframes. Formal adaptive management helps to identify an immediate course of action despite substantial uncertainty. It also helps to clarify the role of monitoring as a process for reducing uncertainty and ranking the performance of management in ameliorating impacts.

One of the most challenging aspects of decision making in natural resource management is the process of identifying and setting management objectives, especially when multiple stakeholders hold conflicting or competing objectives (Step **i** in Figure 1). Environmental management requires decisions makers to integrate heterogeneous technical information with values and judgment. Methods for eliciting and reconciling competing objectives, such as multi-criteria decision analysis (MCDA; Figueira, Greco, Ehrgott, 2005) provide a basis for tackling this challenge. MCDA also provides a coherent way of integrating various forms of uncertainty (epistemic uncertainty, subjectivity, semantic ambiguity; Regan et al., 2001) with social preferences in the decision process. The methods and tools reviewed in the paper (adaptive management, Bayesian approaches, population modeling) are important tool for characterizing and reducing uncertainty that feed

into the decision making process. However, they do not make decisions *per se* because decision making is, necessarily, a social process that involves competing decision priorities. The common purpose of MCDA methods is to evaluate and choose among alternatives, based on multiple criteria using systematic analysis that overcomes the limitations of the unstructured individual or group decision making (Figueira et al., 2005). The aim of MCDA is to facilitate decision makers' learning about and understanding of the problem as well as about organizational preferences, values and objectives. MCDA can guide decision makers in identifying a preferred course of action through exploring these issues in the context of a structured decision analysis framework. MCDA framework may be integrated with adaptive management (Linkov et al., 2006a, b) as well as with Bayesian methods and population models. A detailed review of MCDA and associated methods is beyond the scope of this article. Here I focus primarily on approaches to characterizing and where possible, reducing uncertainty with efficient modeling and learning strategies. I recognize that these are aspects of the larger problem of dealing with uncertainty and social preferences in decision making.

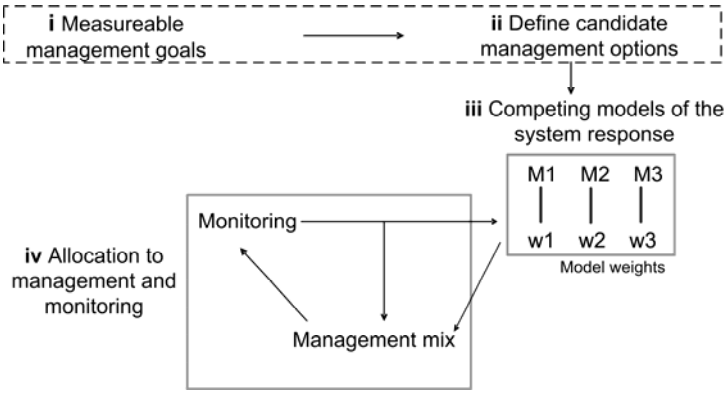


Figure 1. Adaptive management (reproduced from Figure 1, Duncan & Wintle, 2008, © with kind permission of Springer Science+Business Media); an approach to management under uncertainty with a plan for learning. The dashed-line box indicates steps that require elicitation of social preferences. Updating of models can include updating of individual model parameters (e.g. Dorazio & Johnson, 2003) and/or updating of model weights (e.g. Box 2, Johnson et al., 1997).

Population models, impact assessment and adaptive management

Adaptive management of threatened species requires the specification of a model (or competing models) of species' responses to impacts and management intervention. The role of models in adaptive management is twofold. Firstly, models help to characterize uncertainty and formalize competing views about population dynamics, and the manner in which populations respond to anthropogenic influence and interact with natural environmental processes. Secondly models are useful for making predictions about the likely impacts of future (or proposed) management actions, allowing managers and stakeholders to rank competing management options. Under adaptive management, competing

models are iteratively assigned credibility based on the observed response of species to management over time. Population models have been used in both terrestrial and marine systems to evaluate the long-term population consequences of competing management options (Box 1; Akcakaya, Radeloff, Mladenoff & He, 2004; Taylor & Plater, 2001; Wade, 1998; Wintle, Bekessy, Pearce, Veneir & Chisholm, 2005).

Box 1. The use of population modeling to rank management options: The wedge-tailed eagle and plantation conversion in northeastern Tasmania, Australia.

Bekessy et al. (in review) utilized dynamic landscape metapopulation models (DLMP: Akcakaya et al., 2004; Wintle et al., 2005) to assess the landscape-level impacts of plantation conversion on the viability of the wedge-tailed eagle in the north-east region of Tasmania. DLMP were fitted in the software package RAMAS Landscape (Akcakaya et al., 2004). The process of developing DLMP models may be broadly described in 4 steps (Wintle et al., 2005): (1) building a habitat model; (2) developing a model of population dynamics; (3) linking these models in a metapopulation model; and (4) building a forest-dynamics model and linking it to the metapopulation model to evaluate management options.

Bekessy et al. (in review) were able to use the DLMP framework to provide predictions about the future (160- year time horizon) wedge-tailed eagle population size in north eastern Tasmania under a range of forest management and plantation conversion scenarios including: (1) no logging (only 'natural fire disturbance'); (2) native forest harvesting only; and (3) native forest harvesting with extensive plantation conversion (~50% of total forest extent). Results of DLMP models were summarized using the expected minimum population size (EMP: see main text). The results of the DLMP risk assessment process indicated that all anthropogenic disturbance scenarios generated an EMP that was approximately half that of the no-logging scenarios (Fig. 1.1), but that there were no appreciable differences between native harvest-only and conversion scenarios for this particular species. This was thought to be because the primary limiting resource for the species was the availability of nesting habitat that only occurs in old, relatively undisturbed forest on sites with large trees, and that these conditions were approximately equally compromised by native forest harvesting and plantation conversion.

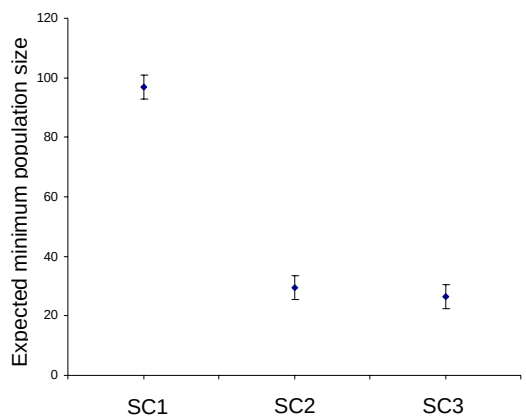


Figure 1.1. Expected minimum wedge-tailed eagle population sizes over a 160-year time horizon under three management scenarios (SC1 = no logging or plantation conversion, SC2 = only native forestry logging with natural regeneration, SC3 = native forestry with natural regeneration and approximately 30% plantation conversion). Error bars represent the 95% confidence interval on the mean EMP (this should not be confused with a 95% prediction interval for EMP). EMP may be interpreted as there being a 50% chance of the population falling below the stated level at some time over the next 160 years.

However, predictions of population models are subject to substantial uncertainty in parameter estimates (Ludwig, 1996). The standard approach to quantifying and representing such uncertainty is through Monte Carlo simulation. Monte Carlo methods are widely used for simulating the behavior of various physical and mathematical systems. Monte Carlo simulation of population models involves randomly sampling parameter values from a distribution of possible values over a number of 'iterations'. For example, when conducting Monte Carlo simulations for a population model, the value of the adult yearly survival parameter at *each time step* might be selected from a beta distribution with a mean set at the best estimate of yearly survival and a variance determined by analyzing long-run variation in yearly survival of the species. Often it is the variance of such parameters that is hardest to determine. A single iteration of the model provides a single possible trajectory for the species. Over numerous iterations, a distribution of predictions is derived that represents the predictive uncertainty in expected population trajectory attributable to parameter uncertainty and the more general effects of environmental stochasiticity. For more information about Monte Carlo sampling in population models, see Burgman, Ferson & Akçakaya (1993).

In order to test the sensitivity of model predictions to particular assumptions, one may conduct a sensitivity analysis. There are several different approaches to conducting a sensitivity analysis including random sampling or systematic perturbation of parameter values and analysis of how variation in a given parameter influences model predictions. A common approach to sensitivity analysis involves systematically adjusting individual parameters by a set amount (e.g. +/- 20%), while keeping all other parameters at their estimated mean value, and observing the magnitude of change in model predictions that arise. If the predicted change in expected population size is substantial for a small change in a particular parameter, then the model is said to be 'sensitive' to that parameter. Sensitivity analysis may be used to assess sensitivity of tail risks as well as expected population sizes. Sensitivity analysis is may be used to priorities research into vital rates or environmental parameters to which population projections are most sensitive.

McCarthy & Thompson (2001) proposed the now widely used metric 'expected minimum population size' (EMP) as an appropriate quantity of interest derived from population viability analysis. EMP is calculated by taking the mean of the smallest population size that occurred at over the simulation period for each Monte Carlo iteration of the model. The EMP is useful in ranking scenarios as it provides a good indication of the propensity for population decline but is less sensitive to model assumptions than the metrics *risks of decline* or *risk of extinction* (McCarthy & Thompson, 2001). One particularly useful property of EMP is that it can be used to delineate between management options for species that have almost no probability of going extinct under any option. The sensitivity of the model to a particular parameter, or the sensitivity of the species to a particular management option may be defined in terms of EMP (Wintle et al., 2005):

$S_i = (\mathrm{EMP}_i - \mathrm{EMP}_b)/\mathrm{EMP}_b \times 100,$

where S_i is the sensitivity of model i (the model being investigated), EMP_i is the expected minimum population size of the model i, and EMP_b is the expected minimum population size of the base model. The base model usually represents the model for which parameter estimates are all 'best' estimates or the model representing the default (or current) management. Sensitivity calculated in this way provides an indication of both the magnitude and direction (positive or negative) of the change in EMP.

Despite the prevalence of substantial uncertainty, modeling may be useful in challenging stakeholders and managers to clearly state their belief about species population dynamics and the magnitude and mechanisms of anthropogenic impacts. Models represent testable hypotheses that may be improved and updated as new data or knowledge comes to hand. As data are gathered, updated models may begin to provide predictions that are more broadly trusted by managers and stakeholders. In data-poor situations, it is important to make the most of available expertise or 'collateral' data. That is the topic of the next section.

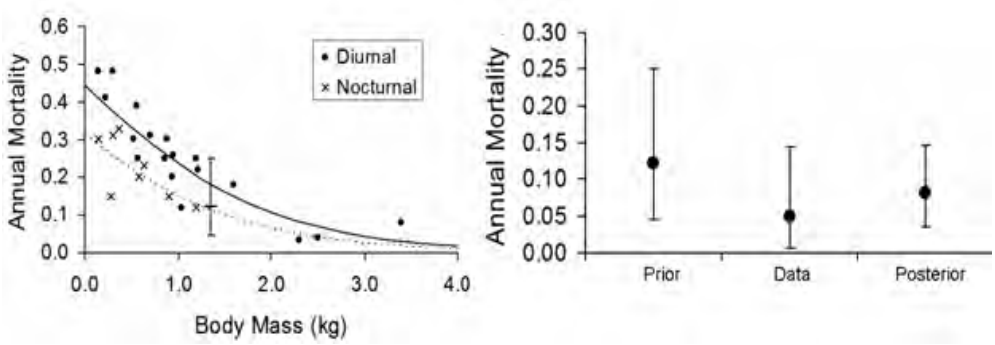
Bayesian approaches to inference

Ecological data are often expensive, time consuming and difficult to collect. Unlike in the physical sciences, the design of the definitive experiment that proves or disproves a theory can seldom be achieved in ecology and conservation. Ecological inference is largely a process of synthesizing disparate data and the results of inconclusive experiments to update knowledge and make the best possible decision. Ecological inference is primarily concerned with estimation of parameters and the weighting of competing hypotheses (models) rather than the rejection or acceptance of null-hypotheses (Anderson, Burnham & Thompson, 2000; Burnham & Anderson, 2002; Ellison, 2004; Johnson, 1999). Bayesian approaches to inference are particularly well suited to the synthesis of disparate information, parameter estimation and multi-model inference (Ellison, 2004; Harwood, 2000; McCarthy, 2007; Wintle, McCarthy, Volinsky & Kavanagh, 2003). Multi-model inference and iterative updating of knowledge (beliefs) are strengths of the Bayesian approach to inference. Ferson (2005) provides an excellent review of the criticisms of Bayesian approaches to inference and decision making, focusing on the use of prior information that is central to the Bayesian method. He identifies concerns about the contraction of uncertainty that arises when highly divergent distributions (i.e. prior and data) are combined with Bayes theorem. There are non-Bayesian alternatives to integrating multiple sources of information (e.g. meta-analysis; Sutton, Jones, Abrams, Sheldon & Song, 2000) and conducting multi-model inference (Burnham & Anderson, 2002), though they are regarded as theoretically less coherent by some authors (Link & Barker, 2006). A full review of the philosophical and practical differences between Bayesian and alternative analytical methods is beyond the scope of this paper. I also consider that the 'controversy' over Bayesian and non-Bayesian methods to be somewhat over-played and to be largely irrelevant here. However, warnings about Bayesian methods should not be ignored because, as is the case for all statistical methods, naïve applications of Bayes theorem can be dangerous. In the following two

sections I discuss two important functions of Bayesian inference in model-based management of threatened species. In the first section I discuss Bayesian approaches to reducing uncertainty through integration of alternative data sources and expert knowledge. In the second section I describe the role of Bayesian updating for iteratively assigning plausibility to competing management models under adaptive management.

Bayesian approaches to reducing uncertainty with prior data and expert opinion

Under adaptive management of noise-effects on cetaceans it is necessary to generate hypotheses and models that describe both the impacts of noise on cetacean population parameters as well as the value of proposed noise mitigation or management strategies. This can be particularly challenging in the absence of definitive studies or models that measure such processes, as is currently the situation with the case in point. McCarthy (2007; pg 134) provides an excellent example of how to develop informative prior information about the value of a poorly measured parameter (in this case, the yearly mortality rate of powerful owls in southeastern Australia). McCarthy utilized a regression of body mass on mortality rate using data for a range of (better studied) raptors from around the world. In his analysis McCarthy demonstrates the use and value of a model-based prior when making inference based on an extremely sparse data (in this case, one observed mortality in 35 observation years: Figure 2).



a. b.

Figure 2. a) Annual mortality of raptors versus body mass for diurnal (solid line) and nocturnal (broken line) raptors. The prediction and prediction interval for the powerful owl, based on the regression for other owls, is shown as the dashes and vertical bar. b) Annual mortality of powerful owls showing the prior based on other species' mortality estimates (a), the data on powerful owls and the posterior estimate (circles are means and dashes delimit 95% CIs) [reproduced with permission of Michael McCarthy and Cambridge University Press].

Box 2. Using Bayes' theorem to assign credibility to competing models with monitoring data; the management of Mallard ducks.

Models that predict a system response to management actions are needed to optimize management decisions (Nichols & Williams, 2006). Typically, multiple competing views (opinions, hypotheses) about how a system will respond to management exist and these views can be formalized as competing models. The plausibility of competing models may be assessed by comparing their predictions to data obtained from monitoring. In developing an adaptive management strategy for Mallard duck harvest, Johnson *et al*. (1997) describe a process of updating belief about the plausibility of competing models based on Bayes' theorem, such that the plausibility of a given model given the newly observed data (D) is:

$$\Pr(M_i \mid D) = \frac{\Pr(D \mid M_i)\Pr(M_i)}{\sum_{j=1}^{s} \Pr(D \mid M_j)\Pr(M_j)}, \qquad \text{(eq 1)}$$

where $\Pr(M_i \mid D)$ is known as the 'posterior probability' or 'weight' of model M_i (i.e. the degree of belief in M_i *after* considering the available data). $\Pr(D|M_i)$ is the likelihood that a given set of data would be observed if M_i were true, $\Pr(M_i)$ is the prior probability assigned to model M_i and the denominator represents the sum across the products of prior probabilities and likelihoods for all competing models including model M_i.

Models describing duck population responses to hunting pressure are central to the sustainable management of duck harvests. Managers of Mallard ducks use equation 1 to iteratively update their belief in competing models as yearly monitoring data are collected (Johnson et al., 1997; Johnson & Williams, 1999; USFWS, 1999). Various scientists and stakeholders hold alternative views about how duck hunting impacts on duck population dynamics. Debate focused on whether population growth would compensate for harvest mortality (compensatory mortality vs. additive mortality) and whether reproductive success would be strongly or weakly linked to habitat availability (strong vs. weak density dependence). In developing an adaptive management system for duck hunting, competing views were summarized as four models of duck hunting population response: 1) additive mortality (am), strong density-dependent recruitment (sdd); 2) additive mortality, weak density-dependent recruitment (wdd); 3) compensatory mortality (cm), strongly density-dependent recruitment; and 4) compensatory mortality, weak density-dependent recruitment (USFWS, 1999).

The implication of strong density dependence and compensatory hunting mortality is that higher hunting quotas may be sustainable. More conservative harvesting may be warranted if density dependence is low and hunting mortality is not compensated by increased reproductive success and a reduction in other forms of mortality. Table 2.1 shows how model probabilities were updated with duck population monitoring data over the years 1995 - 1999. Note that prior to the collection of monitoring data in 1995, all models shared equal prior probability [i.e. $\Pr(M_i) = 0.25$]. As monitoring data were collected and compared against the predictions of the four competing models, it rapidly became apparent that the compensatory mortality hypothesis was not supported by the data as hunting had a substantial impact on overall survivorship estimates. The data provided slightly more support for strong density dependence than weak.

Table 2.1
Trends in probabilities for competing hypotheses of Mallard population dynamics taken from USFWS (1999) [model probabilities have been rounded to two decimal places].

Year	'95	'96	'97	'98	'99
Model (defined above)					
1 (am, sdd)	0.25	0.65	0.53	0.61	0.61
2 (am, wdd)	0.25	0.35	0.46	0.39	0.38
3 (cm, sdd)	0.25	0.00	0.00	0.00	0.00
4 (cm, wdd)	0.25	0.00	0.00	0.00	0.00

The above example illustrates how it is possible to derive parameter estimates where little or no data are available. Approaches to eliciting Bayesian estimates of parameters from experts where no data can be obtained are analogous to those described in this simple example (see Martin et al., 2005; McCarthy, 2007 on soliciting subjective priors). A similar analysis might be initiated to develop parameters that describe the survival and fecundity of species in other situations, such as whales under various noise exposure/management scenarios. The approach outlined above is a logically coherent approach to extrapolating, for example, noise-related impacts from other mammals to cetaceans. The degree to which this approach works depends on whether the responses in question (e.g., behavioral, physiological, psychological, etc.) are highly conserved between species. For example, stress response physiology does appear to be highly conserved between species (see Deak, this issue; Romero & Butler, this issue) and thus would be a good candidate for this approach.

Bayesian updating in adaptive management. Adaptive management encourages a formal process of iteratively updating degrees of belief in competing hypotheses (models) in light of evidence collected through monitoring. There is usually substantial uncertainty about how a species will respond to management intervention, or indeed, the ecological/biological processes that mediate that response. It is common for different experts to support qualitatively different models of ecological processes. Qualitatively different management strategies usually imply different views about how species and environmental processes interact with human and natural disturbances. When appropriate experts support qualitatively different models, it implies substantial uncertainty about the best approach for achieving desired management outcomes. When such uncertainty exists (and is acknowledged), there is value in implementing management options that will facilitate learning about the relative merits of competing models and ultimately the best long-term strategies for achieving management goals. In some instances, data and expert opinion may favor some models over others. When this is the case, formal methods for weighting competing models may be utilized (Box 2; Burnham & Anderson, 1998; Wintle et al., 2003). Competing model weights may be used to assist in the allocation of effort between competing management options. If there is no substantial evidence in favor of one model over another, then uninformative (equal) model weights may be appropriate until further evidence arises that provides support for one model over others (Box 2).

Conclusions

At first glance, the range of tools and the technical aspects of formal decision making may serve as a disincentive to engage in adaptive management. Here I have focused on techniques for making predictions, characterizing uncertainty, and learning about effective ways to manage threatened species. There are substantial components of the decision making process, such as reconciling competing objectives and social utilities that I have not dealt with in detail. While there are technical challenges to all decision analysis methods, the advantages gained in terms of transparency, repeatability and stakeholder trust far outweigh

the technical overheads. In short, dealing with uncertainty in conservation and natural resource management is a difficult challenge that necessitates sophisticated methods. The number of examples of adaptive management and formal decision theory applications occurring in conservation and environmental management are gradually increasing, though much un-chartered territory remains. A systematic method of combining quantitative and qualitative inputs from scientific studies of risk, cost and cost–benefit analyses, and stakeholder views has yet to be fully developed for environmental decision making (Linkov et al., 2006a). Management of threatened cetacean populations and the acute and chronic impacts of noise will involve numerous sources of uncertainty. This highlights the need for systematic approaches to learning and decision making. I encourage cetacean conservation managers to embrace the principles and tools of adaptive management as a means to efficient use of scarce conservation resources and better long-term conservation outcomes.

References

Akçakaya, H. R., Radeloff, V. C., Mladenoff, D. J., & He, H. S. (2004). Integrating landscape and metapopulation modeling approaches: Viability of the Sharp-tailed Grouse in a dynamic landscape. *Conservation Biology,* **18,** 536-527.

Allan, C., & A. Curtis. (2005). Nipped in the bud: Why regional scale adaptive management is not blooming. *Environmental Management,* **36**, 414-425.

Anderson, D. R., Burnham, K. P., & Thompson, W. L. (2000). Null hypothesis testing: Problems, prevalence and an alternative. *Journal of Wildlife Management,* **64**, 912-923.

Bateson, M. (2007). Environmental noise and decision making: possible implications of increases in anthropogenic noise for information processing in marine mammals. *International Journal of Comparative Psychology*., **this issue**, 169-178.

Beale, C. M. (2007). The behavioral ecology of disturbance responses. *International Journal of Comparative Psychology*, **this issue**, 111-120.

Bekessy, S. A., Wintle, B. A., Gordon, A., Fox, J. C., Brown, B., Mooney, N., & Burgman, M. A. (in review). Tasmanian wedge-tailed eagle (*Aquila audax fleayi*) at risk of local extinction from unnatural mortality and forestry operations. *Austral Ecology*.

Bruntland, G. (Ed). (1987). *Our common future: The World Commission on Environment and Development*. Oxford, UK: Oxford University Press

Burgman, M. A., Ferson, S., & Akçakaya, H. R. (1993). *Risk assessment in conservation biology*, London: Chapman and Hall.

Burnham, K. P. & Anderson, D. R. (2002). *Model selection and multimodel inference: A practical information-theoretic approach, 2nd edition*, New York: Springer.

Deak, T. (2007). From classic aspects of the stress response to neuroinflammation and sickness: Implications for individuals and offspring of diverse species. *International Journal of Comparative Psychology*, **this issue**, 96-110.

Dorazio, R. M., & Johnson, F. A. (2003). Bayesian inference and decision theory- A framework for decision making in natural resource management. *Ecological Applications,* **13**, 556-563.

Duncan, D., & Wintle, B. A. (2008). Towards adaptive management of native vegetation in regional landscapes. In C. Pettit, Bishop, I., Cartwright, W., Duncan, D., Lowell, K. & D. Pullar (Eds.), *Landscape Analysis and Visualisation. Spatial Models for Natural Resource Management and Planning*. (pp. 159-182). Berlin: Springer.

Ellison, A. M. (2004). Bayesian methods in ecology. *Ecology Letters,* **7**, 509-520.

Ferson, S. 2005. Bayesian methods in risk assessment. Report for Service Environnement & Procédés, Bureau de Recherches Géologiques et Minières (BRGM), Orléans, France. www.ramas.com/bayes.pdf

Figueira J, Greco S, Ehrgott, M. Eds. (2005). *Multiple criteria decision analysis: State of the art surveys*. New York (NY): Springer.

Gerber, L. R., Beger, M., McCarthy, M. A., & Possingham, H. P. (2005). A theory for optimal monitoring of marine reserves. *Ecology Letters,* **8**, 829-837.

Hauser, C. E., Pople, A. R., & Possingham, H. P. (2006). Should managed populations be monitored every year? *Ecological Applications,* **16**, 807–819.

Harwood, J. (2000). Risk assessment and decision analysis in conservation. *Biological Conservation,* **95**, 219-226.

Holling, C. S. (1978). *Adaptive environmental assessment and management*. New York, New York, USA: John Wiley.

Johnson, D. H. (1999). The insignificance of statistical significance testing. *Journal of Wildlife Management,* **63**, 763-772.

Johnson, F., & Williams, K. (1999). Protocol and practice in the adaptive management of waterfowl harvests. *Conservation Ecology, 3*, 8. Retrieved 27 September 2007, from URL: http://www.consecol.org/vol3/iss1/art8/.

Johnson, F. A., Moore, C. T., Kendall, W. T., Dubovsky, J. A., Caithamer, D. F., Kelley, J. R., & Williams, B. K. (1997). Uncertainty and the management of mallard harvests. *Journal of Wildlife Management,* **61**, 202-216.

Lusseau D., & Bejder, L. (2007). The long-term consequences of short-term responses to disturbance: Experiences from whalewatching impact assessment. *International Journal of Comparative Psychology*, **this issue**, 228-236.

Linkov, I., Satterstrom, F. K., Kiker, G. A., & Bridges, T. S. (2006a). From optimization to adaptation: Shifting paradigms in environmental management and their application to remedial decisions. *Integrated Environmental Assessment and Management,* **2**, 92-98.

Linkov, I., Satterstrom, K., Kiker, Batchelor, C., G., & Bridges, T. (2006b). From Comparative Risk Assessment to Multi-Criteria Decision Analysis and Adaptive Management: Recent Developments and Applications. *Environment International* **32**: 1072-1093.

Ludwig, D. (1996). Uncertainty and the assessment of extinction probabilities. *Ecological Applications,* **6,** 1067-1076.

Martin, T. G., Wintle, B. A., Low Choy, S., Kuhnert, P., Rhodes, J. M., Field, S. A., & Possingham, H. P. (2005). Zero tolerance ecology: Improving ecological inference by modeling the sources of excess zero observations. *Ecology Letters,* **8**, 1235-1246.

McCarthy, M. A. (2007). Bayesian methods for Ecology. Cambridge, UK: Cambridge University Press.

McCarthy, M. A., & Possingham, H. P. (2007). Active adaptive management for conservation. *Conservation Biology,* **21**, 956–963.

McCarthy, M. A., & Thompson, C. (2001). Expected minimum population size as a measure of threat. *Animal Conservation,* **4**, 351-355.

Moilanen, A., & Wintle, B. A. (2006). Uncertainty analysis favours selection of spatially aggregated reserve networks. *Biological Conservation,* **129**, 427-434.

Nichols, J. D., & Williams, B. K. (2006). Monitoring for conservation. *Trends in Ecology and Evolution,* **21**, 668-673.

Regan, H. M., Colyvan, M., & Burgman, M. A. (2001). A taxonomy and treatment of uncertainty for ecology and conservation biology. *Ecological Applications* **12***:*618-628.

Regan, H. M., Ben-Haim, Y., Langford, B., Wilson, W. G., Lundberg, P., Andelman, S. J., & Burgman, M. A. (2005). Robust decision making under severe uncertainty for conservation decision making. *Ecological Applications,* **15**, 1471-1477.

Romero, L. M., & Butler, L. K. (2007). Endocrinology of stress. *International Journal of Comparative Psychology*, **this issue**, 89-95.

Stern, N. (2007). *The Economics of Climate Change: The Stern Review*. Cambridge, UK: Cambridge University Press.

Stankey, G. H., Bormann, B. T., Ryan, C., Shindler, B., Sturtevan, V., Clark, R. N. & Philpot, C. (2003) Adaptive management and the Northwest Forest Plan; rhetoric and reality. *Journal of Forestry,* **101**, 40-46.

Stankey G. H., Clark R. N. and Bormann B. T. (2005) *Adaptive management of natural resources: Theory, concepts, and management institutions*. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR.

Sutton, A. J., Jones, D. R., Abrams, K. R., Sheldon,T.A., & Song, F. (2000) *Methods for Meta-analysis in Medical Research*. London. John Wiley.

Taylor, M., & Plater, B. (2001). *Population Viability Analysis for the Southern Resident Population of the Killer Whale (Orcinus orca)*. Tucson, Arizona, USA: The Center for Biological Diversity.

U.S. Fish & Wildlife Service. (1999). *Adaptive harvest management – 1999 duckhunting season*. Washington, D.C., USA. U.S. Department of the Interior.

Wade, P. R. (1998). Calculating limits to the allowable human caused mortality of cetaceans and pinnipeds. *Marine Mammal Science,* **14**(1), 1–37.

Walters, C., & Holling, C. S. (1990). Large-scale management experiments and learning by doing. *Ecology,* **71**, 2060-2068.

Walters, C. J. (1986). *Adaptive management of renewable resources.* New York, New York, USA: MacMillan.

Wintle, B. A., Bekessy, S. A., Pearce, J. L., Veneir, L. A., & Chisholm, R. A. (2005). Utility of Dynamic Landscape Metapopulation Models for Sustainable Forest Management. *Conservation Biology,* **19**, 1930-1943.

Wintle, B. A., McCarthy, M. A., Volinsky, C. T., & Kavanagh, R. P. (2003). The use of Bayesian Model Averaging to better represent the uncertainty in ecological models. *Conservation Biology,* **17**, 1579-1590.

Wright, A. J., Aguilar Soto, N., Baldwin, A. L., Bateson, M., Beale, C., Clark, C., et al. (2007b). Do marine mammals experience stress related to anthropogenic noise? *International Journal of Comparative Psychology*, **this issue**, 275-317.

International Journal of Comparative Psychology, 2007, **20**, 250-273.
Copyright 2007 by the International Society for Comparative Psychology

Anthropogenic Noise as a Stressor in Animals: A Multidisciplinary Perspective

Andrew J. Wright
Leviathan Sciences, U.S.A.

Natacha Aguilar Soto
La Laguna University, Spain

Ann Linda Baldwin
University of Arizona, U.S.A

Melissa Bateson
Newcastle University, United Kingdom

Colin M. Beale
Macaulay Institute, United Kingdom

Charlotte Clark
Queen Mary, University of London, United Kingdom

Terrence Deak
State University of New York at Binghamton, U.S.A.

Elizabeth F. Edwards
Southwest Fisheries Science Center U.S.A.

Antonio Fernández and Ana Godinho
University of Las Palmas de Gran Canaria, Spain

Leila T. Hatch
Gerry E. Studds Stellwagen Bank National Marine Sanctuary U.S. National Oceanic and Atmospheric Administration, U.S.A.

Antje Kakuschke
GKSS Research Centre, Institute for Coastal Research, Germany

David Lusseau
Dalhousie University, Canada University of Aberdeen, United Kingdom

Daniel Martineau
University of Montreal, Canada

L. Michael Romero
Tufts University, U.S.A.

Linda S. Weilgart
Dalhousie University, Canada

Brendan A. Wintle
University of Melbourne, Australia

Giuseppe Notarbartolo-di-Sciara
Tethys Research Institute, Italy

Vidal Martin
Society for the Study of Cetaceans in the Canary Archipelago (SECAC) / Canary Island Cetacean Museum, Spain

This paper could not have been written without the financial and organizational support from Dieter Paulmann and Jo Hastie respectively. Thanks are also due to 2 anonymous reviewers, whose comments on an earlier version of the manuscript greatly improved the paper. The views expressed in this paper are those of the authors alone and do not represent those of Stellwagen Bank National Marine Sanctuary, the U.S. National Marine Sanctuary Program, Southwest Fisheries Science Center, the U.S. National Marine Fisheries Service, NOAA and/or any other institution or agency. Correspondence concerning this article should be addressed to Andrew Wright, Leviathan Sciences, U.S.A. (marinebrit@gmail.com).

Consequences of extreme noise exposure are obvious and usually taken into some consideration in the management of many human activities that affect either human or animal populations. However, the more subtle effects such as masking, annoyance and changes in behavior are often overlooked, especially in animals, because these subtleties can be very difficult to detect. To better understand the possible consequences of exposure to noise, this review draws from the available information on human and animal physiology and psychology, and addresses the importance of context (including physiological and psychological state resulting from any previous stressor exposure) in assessing the true meaning of behavioral responses. The current consensus is that the physiological responses to stressors of various natures are fairly stereotyped across the range of species studied. It is thus expected that exposure to noise can also lead to a physiological stress response in other species either directly or indirectly through annoyance, a secondary stressor. In fact many consequences of exposure to noise can result in a cascade of secondary stressors such as increasing the ambiguity in received signals or causing animals to leave a resourceful area, all with potential negative if not disastrous consequences. The context in which stressors are presented was found to be important not only in affecting behavioral responses, but also in affecting the physiological and psychological responses. Young animals may be particularly sensitive to stressors for a number of reasons including the sensitivity of their still-developing brains. Additionally, short exposure to stressors may result in long-term consequences. Furthermore, physiological acclimation to noise exposure cannot be determined from apparent behavioral reactions alone due to contextual influence, and negative impacts may persist or increase as a consequence of such behavioral changes. Despite the lack of information available to managers, uncertainty analysis and modeling tools can be coupled with adaptive management strategies to support decision making and continuous improvements to managing the impacts of noise on free-ranging animals.

Physiological responses to stressors and the consequences for an individual or a population have been debated in various arenas, partly because they are studied by scientists from widely different disciplines. Here we summarize the knowledge acquired over the recent decades in different disciplines ranging from animal physiology to human psychology. Noise is a ubiquitous stimulus with the potential to act as a stressor, which has been growing in intensity in the oceans over recent decades. Paradoxically however, the effects of noise on the health and wellbeing of humans, terrestrial animals and, most recently, marine animals remain controversial. This paper provides an overview of the physiological responses to various stressors in humans and animals across various scientific fields and their consequences. We also summarize the current state of knowledge about these responses with specific regard to noise in humans and laboratory animals. Then, we extrapolate from this overview to fill some of the gaps concerning the physiological responses induced by noise in humans and free-ranging animals, highlighting marine species as they often rely heavily on acoustical communication as light does not travel far in water (Hatch & Wright, this issue). The importance of the context in which stressors are presented is also emphasized. Finally, we attempt to identify how and to what extent noise affects the health, wellbeing and viability of wildlife populations. Working definitions of several terms related to "stress" used throughout this paper are presented in Wright & Kuczaj (this issue).

Noise levels and exposure to those levels are measured differently in air and water. The reasons for this are varied, complex and beyond the scope of this paper. More information can be found in Clark & Stansfeld (this issue) and Hatch & Wright (this issue).

Physiological Stress Responses

Pathways of response

Two major systems are known to be involved in stress: the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenal (HPA) axis. These systems are activated very rapidly and have broad impacts on diverse aspects of physiological functioning. The concerted effort of these and other critical endocrine and neural systems ultimately comprises an organism's response to a stressor (see Deak, this issue; Romero & Butler, this issue). Indirect measures of SNS activation (e.g., increased heart rate, blood pressure, or hyperthermia) or direct measures of SNS output from the adrenal medulla (plasma concentrations of catecholamines – epinephrine and norepinephrine) and HPA activation (corticosteroid concentrations in plasma, tissue or excrement) are often collectively or individually used to indicate the severity of a stressor. Importantly, "stress responses" can also occur to stimuli that are merely arousing, such as sexual activity (see Deak, this issue). Thus to avoid misinterpretation of physiological and behavioral measures observers should take into consideration baseline information and should verify the presence of a threatening context to determine whether the observed changes actually reflect a stress response and not arousal *per se*.

The SNS response to stressors can be detected within seconds of the perception of a punctate stressor (i.e., one with a sharp onset). However, many stressors are not punctate but rather develop over a long period. In the cases of these building stressors, the SNS activation is often described as a steadily escalating "tone" where general SNS activity increases relatively slowly over the course of hours, days or months, leading to escalated metabolic demand and gradual wear-and-tear on physiological systems that may eventually culminate into physiological failures (see Deak, this issue). These contrasting SNS responses make it particularly difficult to identify a causal relationship between anthropogenic noise and SNS response because anthropogenic noise arises across a wide range of time frames. Noise can be punctate, such as occurs in seismic survey blasts, or noise can gradually increase over a given area and persist for extended periods (if not permanently), such as is the case with the increase in ambient noise throughout the world's oceans resulting from shipping traffic. In the latter situation, the major stressor is unlikely to be the noise itself, unless levels cross some threshold of tolerability, but rather the increasing masking (i.e., the "drowning out" of a signal in the noise) of mating calls, social communication, echolocation of prey and other important signals.

Development of the response by the HPA axis is somewhat slower than that of the SNS response, but its impact is just as profound, albeit on a somewhat more protracted timeline. Immediately upon perception of a stressor a chain of events in the HPA axis triggers the production of glucocorticoids (GCs: e.g., corticosteroid) by the adrenal cortex (see Deak, this issue; Romero & Butler, this issue). The stress hormones are then quickly released into the bloodstream (usually within 3-5 min after activation by stressor onset) where they are rapidly distributed throughout the body to initiate a systemic response to the threat (Romero & Butler,

this issue; Sapolsky, Romero, & Munck, 2000). This can be problematic for researchers as it limits the time during which they can gain valid information on GC levels, as an animal's blood GC levels rises very quickly after the individual perceives the threat of capture, regardless of whether it is yet in hand or not.

In general, the more intense the stressor, the greater the amount of GC released. Once the stressor ends, GC levels return to baseline concentrations as a consequence of both the ending of the stimulus and GC negative feedback on the pituitary gland and hypothalamus (see Romero & Butler, this issue). If the stressor persists or occurs at frequent intervals the animal becomes chronically stressed (how frequent depends upon the stressor). This is generally manifested as a long-term increase in GC secretion due to two mechanisms: repeated secretion in response to repeated stressors and a failure of GC negative feedback (Dallman & Bhatnagar, 2001).

Consequences of the stress response

GCs (both independently and in combination with other components of the stress response) cause a variety of behaviors in free-living animals that are heavily context dependent (see Deak, this issue; Romero & Butler, this issue). However, the broad effects of GCs are to shift the animal away from normal life-history behavior to emergency behaviors (see Romero & Butler, this issue). Examples include increasing activity, the scattering of a group, shifting behavior from reproduction to feeding, and abandonment of breeding territories. These behaviors are adaptive in natural environment in the short-term, but may become maladaptive in response to novel human disturbances and/or repeated or chronic exposures.

Detrimental physiological effects can also appear if the stressors remain, or additional stressors are presented, prolonging the GC response over an extended period. A number of pathological effects appear after 2-3 weeks, which are very consistent across species studied (mainly in captivity: see Romero & Bulter, this issue). These include, but are not limited to, diabetes, immune suppression and reproductive malfunction. In fact, the assault on reproductive function is threefold, involving prolonged behavioral changes, such as reorientation of the individual's behavior away from reproduction, psychological effects, such as decreases in libido, and physiological impairment of reproduction (see Deak, this issue; Romero & Butler, this issue). Interestingly, in many human couples seeking artificial conception, the underlying infertility is induced by being stressed (Homan, Davies & Norman, 2007; Wischmann, 2003).

Other long-term consequences of persistent high GC levels include accelerated aging and a slow disintegration of body condition (see Romero & Bulter, this issue). It is clear that accelerated aging in combination with decreased reproductive function presents a double-blow to the fitness of an individual. There are obvious implications for the population if such effects are widespread, but more subtle consequences also exist (see Deak, this issue; Romero & Butler, this issue). For example, if cultural exchange from one generation to the next is limited by the shortened lifespan and premature death of the older generation, certain skills

or valuable information (e.g., regarding a reliable watering hole in times of drought in elephants) may be lost.

One further example of the consequences of persistently elevated GC levels is psychosocial dwarfism (Green, Campbell & David, 1984), a rare but documented inhibition of growth in human children due to altered growth hormone function (see Romero & Butler, this issue). It appears possible (although speculative at this point) that prolonged high levels of GCs may explain why sperm whales (*Physeter macrocephalus*) in the Gulf of Mexico (GoM) are significantly smaller than others elsewhere in the world (Jaquet 2000). Humans have very extensively used the Gulf ever since the discovery of the Mississippi River: activity that has continuously intensified.[1] The apparent dwarfism in the resident sperm whales might be a symptom of the heavily stressed state of the animals due to that activity. This condition would probably not be the result of exposure to noise alone, but rather the cumulative action of noise with various other stressors such as reduced prey availability and contaminants. Genetic differences and other factors might also be involved.

GCs can also have toxic consequences for neurons (i.e., cause neuron death) in the very young brain, which is probably why GC responses to stress are attenuated during the perinatal period (Sapolsky, 1992). Only severe stressors elicit GC release by the newborn during this time, such as parental deprivation or neglect, possibly as a consequence of parental/alloparental poor health (for any reason), or maternal separation, perhaps due to increased foraging times. The period of attenuation extends up to about a week or two postpartum in rats, but its length is not known in many other species, including marine mammals. If the mother is exposed to severe stressors however, GCs may be passed to the offspring through the placenta or in milk, circumventing this attenuating mechanism. The damage caused by exposure of the young brain to GCs produced by the mother alone can have profound and permanent consequences for the offspring, including sensitizing them to stressors, that is increasing their GC response, later in life (Kapoor, Dunn, Kostaki, Andrews & Matthews, 2006). Such changes can last at least to young adulthood and may be permanent, introducing the specter of potential generational effects.

Once this attenuation period ends, the still developing brain may then be very susceptible to neurological damage and re-programming as a result of exposure to high GC levels, whatever the source. Consequently, while reasonably mild stressors can lead to mild and temporary stress responses in adult animals, similar exposure in very young animals, either directly (e.g., brief handling of neonates, for not more that 2-3 minutes per day) or indirectly (e.g., through a "stressed" mother), has the potential to elicit long-term, if not permanent, consequences for the individuals resilience to stressors.

Long-term consequences of a prolonged or repeated stress response may also be present in individuals of any age due to ways that GCs instigate changes in

[1] For more information on human activity in the GoM see the EPA Gulf of Mexico Program website (http://www.epa.gov/gmpo/about/facts.html#maritime), Lynch & Risotto (1985) and Melancon, Bongiovanni & Baud (2003).

the body. In order to have any effects GCs, like other steroids, must first pass through the cell wall. Once inside the cell nucleus, GCs bind with their receptor and they rewrite protein construction priorities (i.e., reprogram the expression of various genes). These revisions can persist long after high GCs levels have ceased circulating in the blood, thus long after the removal of the stressor. This persistence combined with the rapid activation of both the SNS and HPA axis responses means that many of the delayed and/or long-term consequences of stressor exposure are induced as a direct consequence of the initial perception of even a brief punctate stressor.

Effects of combining stressor types

The brain appears to classify threats as being processive (psychological) or systemic (physiological) in nature (see Deak, this issue). Psychological stressors include threats like predators, while physiological stressors include immediate and severe threats to physiological homeostasis, such as hypoglycemia (low blood sugar, specifically glucose). Importantly, some stressors appear to activate brain systems involved with both classes of stressors and it is these "compound" stressors that appear to produce the most direct outcomes for CNS functioning and overall health (see Deak, this issue).

Either exposure to a single very intense acute stressor, or the cumulative impact of numerous stressors across time, can ultimately lead to expression of sickness-like behavior, which is thought to be a symptom of neuroinflammation (Deak, this issue). For example, separation of a young guinea pig from its mother produces psychological stress (separation anxiety) and the offspring immediately begins to run around and vocalize. However, after an hour of exertion (physical stress), the young guinea pig stops that behavior, shuts it's eyes, curls up and looks sick (Schiml-Webb, Deak, Greenlee, Maken & Hennessy, 2006). This response can be reversed by giving drugs with potent anti-inflammatory properties (Schiml-Webb, Deak, Greenlee, Maken & Hennessy, 2006). It is possible that the stress response and illness may have co-evolved as both are responses to threats (see Deak, this issue).

Normal aging is associated with greater expression of pro-inflammatory factors in the CNS (see Deak, this issue), so that risk of neuroinflammation increases with age. Repeated stressor exposure also leads to inflammatory responses as well as to accelerated aging as discussed above, creating an escalating combination of effects that can lead to increased incidence of neurodegenerative disorders and other critical problems that normally only arise later in life (see Deak, this issue).

Maladaptation of the stress response

Generally speaking, physiological responses to acute stressors promote survival in the face of diverse threats and are therefore viewed as being adaptive. Survival is promoted principally through a preferential re-allocation of resources (blood flow, glucose utilization, cognitive and sensory acuity, etc). The increase in

catecholamines associated with the acute fight-or-flight response has distinct energetic and immune consequences for the individual. The effects of GCs are more prolonged in nature and probably evolved as a mechanism to sustain behavioral and physiological responding to stressors of longer duration. The transient expression of sickness-like behavior after stressor cessation probably represents an adaptive period of recuperation that is necessary to reinstate normal levels of cognitive and behavioral function to pre-stress levels (Deak, this issue). With prolonged or repeated stressor exposure, however, neuroinflammatory consequences of stress can become maladaptive, leading to compromised neuronal function, greater susceptibility to infection (Dhabhar & McEwen, 1997), and ultimately reduced reproductive fitness (see Deak, this issue).

Likewise, failure to mount a GC response can lead to the inability of the animal to continue to respond appropriately to a stressor, subsequently resulting in death (see Romero & Butler, this issue). This failure might be due to over-stimulation from either chronic or intense acute stressors that could have shutdown GC production through negative feedback, and possibly also depleted some of the various precursor molecules and biosynthetic enzymes necessary to produce the GC molecule. Alternatively, a prolonged response or exposure to a persistent stressor, such as pollutants, may have caused damage to the adrenocortical tissue where GCs are produced (Hontela, Rasmussen, Audet, & Chevalier, 1992; Martineau, this issue). Functional abnormalities of chronic stress are not restricted to GC effects. They can also result from catecholamines. For example, long-term activation of the fight-or-flight response across the life span can lead to coronary dysfunction and disease (see Romero & Butler, this issue), an effect that may involve vascular inflammation as an intermediate mechanism (Black, 2002, 2003).

In general, the physiological stress response and the consequences thereof described above are highly conserved between species, including fish, birds and mammals, although the exact basal levels of GCs and other stress hormones are fairly variable from one individual, population or species to another (see Deak, this issue; Martineau, this issue; Romero & Butler, this issue). However, not all stimuli are actually stressors. The distinction is largely a matter of perception by the animal/human. Experience immediately prior to a stimulus plays an important role in the nature and intensity of an animal's response to that stimulus. For example, a very slowly increasing stimulus is easily acclimated to and only becomes a stressor once it exceeds some threshold. Similarly, the stress response is initiated only when events are worse than those expected by an animal (Levine, Goldman & Coover, 1972). Conversely, if a stimulus decreases in frequency or magnitude, the individual perceives an improvement in situation and the stress response will decline, even if the individual is still being subjected to an unpleasant stimulus. Complicating the matter further, the expectation of an unpleasant stimulus may in itself initiate the stress response. Furthermore, acute stressors that normally last a short time (such as predator attacks, dominance interactions and storms) may become chronic stressors if they occur often enough or persist.

Context and Behavioral Responses

Context is thus extremely important in the overall expression of a response to a potential stressor. Innumerable factors combine to form the context: environmental factors, such as season; recent history of incidence of the particular stimulus including intervals (i.e., prior experience); maturity, age, sex and other life history factors; inter- and intra-specific variation (genetic and propensity) including individual sensitivities, resilience and personality; condition (e.g., well-fed or hungry); other stressors currently acting upon an individual (e.g., infection, chemical exposure, etc.); predictability of stressor exposure; behavioral context (e.g., what the animal is doing when subjected to the stimuli); current psychological state (e.g., anxious, optimistic); and social structure.

Behavioral responses as an indicator for stress effects

While many of the above contextual factors may influence the onset and/or magnitude of a physiological stress response, the response itself is reasonably consistent once activated. However, an observed response does not necessarily reflect the magnitude of the impact actually experienced by the animal (Beale, this issue; Beale & Monaghan, 2004; Bejder, Samuels, Whitehead & Gales, 2006; Gill, Norris & Sutherland, 2001; Harrington & Veitch, 1992; Lusseau 2004; NMFS, 1996; Stillman & Goss-Custard 2002; Todd, Stevick, Lien, Marques & Ketten, 1996).

For instance, behavioral reactions may be influenced by the psychological state of the individual. All behavioral decisions (whether conscious or not) are the product of information processing systems within the animal's brain. Stressors, including noise, and their associated emotional states, such as anxiety and depression, may influence this processing in a number of ways. First, anxiety is essentially an early warning system for the fight-or-flight response, and as such is associated with a suite of adaptive changes in cognition. Attention shifts towards awareness of possible threats and ambiguous information is interpreted more pessimistically (see Bateson this volume). These effects may be subtle and reversible, but may significantly affect the actions of an animal while they persist. For example, captive European starlings (*Sturnus vulgaris*) exposed to the stressor of being housed in barren cages may become more pessimistic and risk-averse in their interpretation of cues associated with food rewards. This pessimism is seen in a shift towards preferring safe foraging options, avoiding riskier but potentially more rewarding sites (Bateson & Matheson, 2007; Matheson, Asher & Bateson, 2008). Similar biases induced by other stressors could therefore result in changes in the spatial or temporal pattern of foraging behavior, with knock-on consequences for the fitness of the animals exposed. These changes in behavior also have the potential to place animals in situations where additional stressors could occur, such as food deprivation, or arrival in a novel environment due to avoidance efforts.

Physical condition can also influence behavioral responses. For example, well-fed animals may take fewer risks than their hungry counterparts, preferring a certain food reward over a more variable (i.e. risky) alternative (Caraco et al., 1990). Consequently, these individuals may also appear to be more sensitive to disruption, fleeing from a disturbance source at much greater distances. Conversely, a starving or sick animal may not display any observable response, as they may simply not be able to afford to react behaviorally: this is the only good feeding habitat in the area. Similarly, the well-fed animal may eventually be forced to return to its foraging ground when it becomes hungry, regardless of the potential threats. In this case, the change in behavior reflects a change in the physiological status of the animal.

However, such apparent increases in tolerance have often been used to argue that animals are "habituating" to the source and are thus no longer impacted by it (see below). On the contrary, any individuals (such as the hungry animal described above) remaining in a location in the face of potential danger may be subjected to one or more potential stressors. They may therefore display a number of physiological and epidemiological responses consistent with a stress response. For example, kittiwakes (*Rissa tridactyla*) in Scotland show an increase in heart rate in response to human disturbance. This cardiac reaction has been estimated to increase daily energy expenditure by around 7.5-10% for some individuals, despite a long history of exposure to disturbances in the area (see Beale, this issue). This increase in daily energy expenditure is sufficient to result in eventual abandonment of nesting attempts once energy reserves drop below a critical level.

In summary, a lack of behavioral response could be either because there is no stress felt, or because the animal can't afford, or is not able, to respond overtly. Likewise, a strong behavioral response to a stressor, or a high level of observed response in a population, may mean that the stimulus is a particularly horrible stressor that is to be avoided at all costs, or it may imply that there is very little, if any, cost of responding to the stimulus, even though it may amount to no more than a minor irritation. Thus, given that animals make decisions (consciously or subconsciously) about how and/or whether or not to respond to a stimulus on the basis of their current context, this context must be known to biologists in order to accurately interpret the response intensity to a given stressor. As acquiring this knowledge is fraught with enormous difficulties in practice, it may not be possible at all to make such a determination simply from behavioral observations (see Beale, this issue). However, if such information is cautiously coupled with additional data (e.g., through the application of resource-use models), behavioral measures may allow the absolute minimum cost associated with responding to a stressor to be assessed (see Beale, this issue). Also, behavioral reactions observed in longitudinal studies can be, to some extent, placed in the context in which they occur (such as population abundance trends, residency patterns, season, etc.: e.g., Bejder et al., 2006; Lusseau 2005). These multi-scale approaches can also provide a framework to infer the synergistic costs of multiple stressors (natural and anthropogenic).

Likewise if the context in which decisions are made is not changed between two stressor exposures, behavioral measures can be used directly to

measure the relative degree to which the stressors affect individuals (see Beale, this issue). However, maintaining similarity of context is challenging. Many factors, such as passing predators, changes in prey abundance and distribution (even on a very local scale), and recent experience of any and all other stressors, can be difficult to measure especially in the marine environment. If such experimental approaches are not feasible, these contextual factors need then to be included as model co-factors or accounted for in other ways. One exception occurs if the behavioral responses to a given type of stimulus remain great regardless of the context, which would indicate unambiguously that the species involved attempts to avoid that type of noise at all costs.

Acclimation

The term "habituation" is often used loosely to describe animals "getting used to" a stimulus, with various broad implications. However, "habituation" is often invoked without reference to the literature and seemingly in conflict with the use of the term in the biomedical or psychological literature (see Bejder et al., 2006). To avoid confusion, we shall use the term "acclimation" or "acclimatization", meaning that an animal no longer produces a physiological stress response in reaction to a stimulus (Romero, 2004; Wright & Kuczaj, this issue and references therein). Animals can only truly acclimate in this way to stimuli that they perceive to be the same from one instance to the next, as well as non-life threatening (Romero, 2004; Wright & Kuczaj, this issue and references therein).

Acclimation is more likely to occur with frequently repeated, predictable exposures and can be lost if enough time passes between exposure events. This may explain why laboratory results for acclimation are more consistent than observations in the wild, as what appears to be repeated exposure in the "real world" may not be predictable or perceived as precisely the same by the animal. Chronic stimuli obviously meet the exposure frequency criteria required for an animal to acclimate, however animals may still lose acclimation if the exposure ends and there is enough time before the next exposure begins. The magnitude of exposure is also a consideration, because, in general, the greater the stress response initiated by a stressor, the less likely an animal is to acclimate to it, to the point where animals never acclimate to serious stressors.

In summary, animals will acclimate quicker to stimuli that are perceived to be smaller potential threats than those representing larger possible threats. However, acclimation only eliminates or reduces the stress response. It does not prevent other effects produced by a stimulus, such as hearing loss and masking that result from noise, as well as any stress response that these effects might subsequently induce. Similarly, acclimation also opens the possibility for sensitization, where the animal may produce an enhanced stress response when exposed to a new or different stressor.

Additionally, some uncertainties remain even within the narrower definition of "acclimation" as some humans can continue to perceive a noise as annoying or stressful without physiological responses or vice versa. Also, it's not

clear exactly how similar a sound must be for animals to cease to be able to tell them apart: e.g., different boats may sound very different.

Determining Cumulative Effects

We have already discussed above the potential for one stressor to influence the impacts of a subsequently applied stressor through the alteration of the context of exposure. Accurate prediction of all the potential cumulative and synergistic effects requires a reasonable knowledge of all the various contextual factors for each exposure and is thus not an easy proposition. However, at the most basic level it seems reasonable to conclude that the addition of new stressors is likely to increase the stress response, a concept that has some support in the literature (see review by Dallman & Bhatnagar, 2001).

The cumulative effects of multiple stressors can be estimated in this way through use of the concept of allostasis (see summary in Wright & Kuczaj, this issue; and discussion in Romero, 2004: Box 1 and references within), which suggests that all the various energetic demands that would be placed on an individual can be added up to see if that individual would be able to cope with them (i.e., maintain an allostatic load) or not (i.e., go into allostatic overload). Allostasis is currently a contentious idea in the biomedical world, a debate that goes beyond the scope of this paper. Suffice to say that the use of the concept of allostasis to investigate the cumulative effects of various stressors requires a working knowledge of the size of the energetic demands generated by each stimulus, which is clearly lacking for many species. This is not to say that energetic models cannot be useful in the management of the cumulative effects of various stressors on species where such data are limited, for example marine mammals (e.g., Lusseau, 2004). Rather energetic models are indicators of minimum possible energetic costs because of the various assumptions involved and the limited knowledge of the possible non-linear synergistic interactions between stressors.

Initial efforts to begin considering such non-linear synergistic interaction could be based on the two broad categories of stressors defined earlier, psychological, or processive, and physiological, or systemic, stressors. These categories should be considered because the simultaneous exposure to stressors belonging to each category increases the likelihood of having a severe impact on the individual. For instance, rats exposed to either simple restraint or hypoglycemic challenge show no evidence of neuroinflammation, while rats exposed to both challenges showed profound neuroinflammation (Deak, Bordner, McElderry, Bellamy, Barnum, & Blandino, 2005). Given that neuroinflammation may be a harbinger of adverse long-term health outcomes of stressor exposure, these data indicate that a categorically distinct, synergistic response can be provoked when otherwise innocuous events are combined. This may have profound implications for animals in captivity, which may be exposed to a wide variety of both physiological and psychological stressors such as confinement in a small environment, handling (especially in marine species, where handling is often

accompanied with at least partial removal from water), and the noise and activities of the public, staff, and/or researchers.

Even if both the different types of stressors and their cumulative energetic demands are accounted for, it may still not be possible to predict the overall effect of multiple stressors on an individual because lab-based studies have shown that multiple stressors interact in unpredictable ways to alter GC release, either increasing or decreasing circulating GC levels (see Dallman & Bhatnagar, 2001). Context or the influence of context may also vary unpredictably. Consequently, efforts to determine cumulative and synergistic effects of multiple stressors on animals, though important to pursue, should be undertaken cautiously.

Noise-Induced Stress Responses

Some of the known effects of noise in animals include audiogenic seizures and increases in serum cholesterol levels (Clough, 1982), intestinal inflammation (Baldwin, Primeau, & Johnson, 2006), and increased adrenal weights due to overproduction of adrenal hormones caused by a prolonged stress response (Ulrich-Lai, et al., 2006). Stress responses induced by loud or sharp noises have even lead to cannibalism of neonates, as well as a generally decreased reproductive performance in mice (Michael Rand, pers. comm.).

The stress response with its various effects and impacts has been studied to some extent in rats and humans exposed to noise. For example, laboratory rats exposed daily to short periods of white noise exhibited a variety of conditions consistent with the onset of a physiological stress response after around 2 weeks, becoming more pronounced at 3 weeks (Baldwin, this issue). These conditions included inflammation of the intestinal mucosa and the mesenteric microvessels, degranulation of mast cells in the intestinal mucosa, migration of eosinophils into the wall of the intestine, and oxidative damage. Additionally, exposed rats groomed excessively and had redness around eyes and neck. After a recovery period of 3 weeks, the noise-exposed rats displayed some characteristics similar to unexposed controls, but other characteristics remained similar to pre-recovery conditions, indicating that some pathological effects continued to persist even after removing the noise exposure (Baldwin, this issue).

In humans, noise causes a number of predictable short-term physiological responses such as changes in hormone levels. However, little is known about how these might combine to have long-term consequences on health (see Clark & Stansfeld, this issue). Furthermore, specific evidence of chronic noise effects on adrenaline, noradrenaline and cortisol levels in humans is weak and inconclusive, suffering from various experimental difficulties (see Clark & Stansfeld, this issue). However, there is stronger evidence for a positive association between chronic noise exposure and both hypertension (i.e., raised blood pressure) and coronary heart disease (CHD), including some significant increases in myocardial infarction (i.e., heart attacks) associated with exposure to occupational, road traffic and aircraft noise.

There are indications that some of these effects on health may be mediated through annoyance, itself a psychological stressor (see Clark & Stansfeld, this

issue). In addition, noise exposure (or the annoyance it causes) has been associated with increased reporting of psychological and somatic symptoms in affected populations, but not with more serious clinically diagnosable psychiatric disorders such as anxiety and depressive disorders. This suggests that noise is probably not associated with serious psychological illness, but may affect well-being and quality of life (see Clark & Stansfeld, this issue). However, there have been no longitudinal studies in this area.

Noise may disturb sleep in humans as well, which may in turn have consequences for performance, mood and health. However, it appears that, with regards to sleep disturbance, naïve exposure (i.e., no prior experience) is a very important factor. Regardless of the mechanisms involved, these various effects may contribute to the increase in mortality observed in one study of industrial noise, with additional job-related stressors potentially acting cumulatively with the noise (see Clark & Stansfeld, this issue).

The greater expression of noise-related impacts in workers with higher job-related stressors is one example of the importance of contextual factors and cumulative exposure on the strength of response and ultimate outcomes from exposure to noise or any other stressor. Various other contextual factors are also important in humans in ways that are similar to the influence of prior experience on the physiological stress response of animals (see Clark & Stansfeld, this issue). For example, individuals with poor psychological health prior to exposure to noise reported greater annoyance (Tarnopolsky, Barker, Wiggins, & McLean, 1978), showing that individual psychological traits determine how annoying noise is.

Children may be more vulnerable to the effects of environmental stress as they have less cognitive capacity to understand and anticipate environmental stressors, in addition to lacking well-developed coping repertoires (Stansfeld, Haines, & Brown, 2000). Studies have consistently found that chronic noise negatively affects children's learning and cognitive abilities, and are beginning to indicate an effect on hyperactivity, although evidence for an increase in psychological symptoms is mixed and inconclusive (see Clark & Stansfeld, this issue). Recovery of some of these deficits may be possible if noise exposure ends, but noise could potentially impair child development, resulting in lifelong effects on both educational attainment and health. Longer exposures are known to cause larger and more persistent effects on physical health and are also likely to generate larger cognitive deficits and bigger effects on psychological health (see Clark and Stansfeld, this issue). Furthermore, the consequences for educational attainment are more likely to be long-lived or permanent if exposure overlaps with the closure of any learning window or opportunity (e.g., until a child leaves school).

Acclimation to noise

Given the above considerations on acclimation to stressors in general, apparent behavioral tolerance of noise cannot be automatically interpreted as true physiological acclimation. Instead, apparent behavioral tolerance could be the result of different contexts, such as an overwhelming need for an individual or a population to remain in the area, the absence of alternative habitats, the prohibitive

costs associated with avoidance, or even that the animal might already have reduced hearing at the frequencies of the stimuli. Learning alone (i.e., without an associated reduction in physiological response) might also simulate acclimation to noise. In addition to the above mechanisms, an apparent increase in behavioral tolerance at the population level can arise if the most sensitive animals in the population have already left the area (e.g., Bejder, Samuels, Whitehead, & Gales, 2006). One other possibility is that rapid "natural" selection may have taken place, through the death of either the most sensitive individuals and/or the ones that are most prone to maladaptive alarm/escape responses (for some possible examples of these in marine mammals see Wright et al., this issue, b). The possible long-term costs and benefits of behavioral tolerance as a result of any of these mechanisms are unknown, although the action of either selection or emigration will clearly reduce the number of animals in the local population.

If an animal spends a considerable amount of time reacting to human disturbance, it may be fatigued and not willing or able to evade a potential threat and thus may appear to have acclimated when in fact it has not. Likewise, the apparently quick development of tolerance to disturbances in humans (e.g., aircraft noise in most people sleeping near airports) may not translate into free-ranging animals because animals must remain aware of predators, while humans in contrast are largely spared threats of this kind. Humans also benefit from prior knowledge that the noises can be reliably associated with passing aircraft or road traffic and that these things are unlikely to indicate an imminent threat.

The matter is complicated further still by the concept of "tuning out", a type of filter for chronic, but changing, noise as is seen in humans (see Clark & Stansfeld, this issue). Consider that many patrons in a bustling restaurant largely filter out the general noise of employee activity and the conversations of other diners. This filtering does not prevent other effects, such as masking and hearing loss. Furthermore, it is not clear how much people or animals might perceive the noise as changing. For example, many of the abovementioned diners would look up if they hear a waiter breaking a plate or a glass.

Masking, psychology and behavior

Acoustic signals become ambiguous when they are hard to discriminate from other sounds. Increased environmental noise thus augments the ambiguity of incoming information by either reducing hearing capacity through hearing damage (temporary or permanent) or through masking by increasing background noise levels. Hearing damage persists after exposure (even if only temporarily) and affected animals can do little to compensate for the loss during that time. On the other hand, animals can employ several strategies to limit the ambiguity created by masking (see Bateson, this issue).

One option, physical avoidance, is to leave the noisy area for somewhere quieter. Avoidance strategies are not likely to be feasible for the majority of chronic or high-incidence noises. This is especially true for marine life exposed to ambient noise generated by shipping, which dominates background noise at low frequencies in many of the world's oceans, particularly in the northern hemisphere.

A second option, available if noise is not continuous, is to cease communicating during periods when noise levels are highest. For example, urban European robins (*Erithacus rubecula*) switch to nocturnal singing in areas with high daytime noise (Fuller, Warren & Gaston, 2007). However, such evasive behaviors could again place animals in situations where they will encounter new stressors. In the above example, nocturnal singing could lead to an increased risk of predation by exposure to, or attraction of, nocturnal predators. In any case, temporal and special avoidance strategies can only be employed if the temporal distribution of the noise is predictable.

A third tactic available to animals is to change one or more characteristics of their acoustic signals, such as length, frequency, amplitude, or other acoustic features, to increase their transmission probability in a noisy environment. Beluga whales (*Delphinapterus leucas*) for instance can increase the amplitude of their signals in response to increasing background noise, a response known as the Lombard effect (Scheifele, Andrew, Cooper, Darre, Musiek, & Max, 2005). Humans speaking loudly in noisy situations are employing this option, but will eventually become hoarse and may temporarily lose their voice. It is not known what kind of consequences long-term use of signal-change strategies may have for animals, however increasing the amplitude of a sound uses more energy and therefore carries some additional cost.

The fundamental ability of an animal to actually alter its signals may also be limited, physiologically, anatomically, or by age. Many songbirds, such as the chaffinch (*Fringilla coelebs*), have a narrow window of time in early life in which their brains are particularly receptive to acquisition of new vocal patterns such as song. A few species, such as mockingbirds (*Mimidae*) and European starlings, continue to learn new vocal patterns after this period, while other singers show only limited variation from the parental song after early learning (for a review see Catchpole & Slater, 1995). Similarly, there are indications that bottlenose dolphins (*Tursiops truncatus*) may be able to learn at any time (e.g., Watwood, Owen, Tyack, & Wells, 2005) and male humpback whales (*Megaptera novaeangliae*) are known to change their songs repeatedly throughout their lives (see Noad, Cato, Bryden, Jenner & Jenner, 2000; Payne, Tyack, & Payne, 1983). However, very little is known about the abilities of most other marine species, especially marine mammals that use low frequencies, to acquire new vocal patterns throughout their lifetimes.

In any case, while altered signals may propagate further or be more distinct in the face of increases in ambient noise than unaltered ones, the potential usefulness of signal alteration is limited by the extent to which signals continue to be recognized by the intended receiver. This is especially important when the calls are involved in species recognition, perhaps for mating or maintaining social structure, which may further reduce the extent that these calls can be changed. Alteration of signals may also be problematic in species that communicate over long distances (such as mysticetes – baleen whales), because two animals may be subjected to very different ambient noise profiles. This means that the optimum signaling strategy in the immediate acoustic environment of the signaler may be

very different from the best option given the noise profile in the immediate area of the signal receiver.

Signal alterations are also not an option for animals that hunt using passive acoustics (i.e., eaves-dropping on their prey). Consequently, there will be many occasions when the only option available to an animal will be to alter its responses to incoming sounds. For example, animals can alter their thresholds for responding to incoming sounds that they receive, be they communication signals or sounds made incidentally by prey, predators, or con-specifics (see Bateson, this issue). If increases in masking noise make it harder to discriminate important signals from other irrelevant sounds, then animals may adapt to this situation in different ways, including:

1) Lowering their threshold for a sound to be identified as a particular type of signal, thus increasing their probability of falsely identifying signals as related to mates, prey and/or predators. Possible results include chasing after objects or organisms that are neither prey nor a mate, or fleeing from things that are not a predator (or other threat). This has consequences in terms of increased energetic costs.
2) Increasing their threshold for a sound to be identified as a particular type of signal, thus decreasing their probability of identifying a signal related to a mate, prey and/or a predator. Possible results include increased missed opportunity costs (e.g., passing up on possible prey and potential mates) or increasing the risk of predation if predators are missed.

In summary, animals have a range of options available for mitigating the adverse effects of environmental noise on their use of acoustic information. However, it is important to assess the potential fitness costs of any observed adaptation. Costs may arise from increased energetic expenditure, increased risk of predation, or lost opportunities for feeding or mating. All of these sources of cost could potentially be associated with increased risks of a physiological stress response occurring as animals struggle to adapt to function in a noisy environment.

Management Issues

The stress effects from noise that are of the greatest interest to managers are those that ultimately have consequences for survival and fecundity rates (*vital rates*). Population level impacts are potentially catastrophic but highly uncertain, providing some grounds for a precautionary approach. However, as uncertainty is pervasive in ecology and conservation management, various tools have been developed that attempt to characterize and deal with such uncertainty in decision making processes (see Wintle, this issue). In particular, adaptive management and Bayesian modeling approaches offer some promise (see below and Wintle, this issue).

Management under uncertainty: A general framework

Adaptive management can be loosely defined as management with a plan for learning (Wintle, this issue). The sequential actions in the process of adaptive management should have the dual purpose of achieving management goals and facilitating learning about both the system under management and the relative performance of management actions. Effective adaptive management requires simultaneous implementation of multiple competing hypotheses and/or management actions that are iteratively updated through concurrent assessment and evaluation with monitoring data. Hypothesis generation and modeling may be based on existing data and/or expert opinion.

Adaptive management is appealing as it explicitly acknowledges that the decision being made is subject to uncertainty and may change in the next time step depending on what is discovered (i.e., learned) in the intervening period. Notably, the completion of an experiment is not required before a change to management can be instituted. This allows a more rapid response that is particularly well suited for managing systems in which changes take a long time to become apparent.

Population modeling and scenario analysis

Adaptive management of anthropogenic impacts on any species requires the construction of a model (or competing models) of species' responses to those impacts and any management intervention. Population models have been used in both terrestrial and marine systems to evaluate the long-term population consequences of competing management options (Akçakaya, Radeloff, Mladenoff & He, 2004; Taylor & Plater, 2001; Wade, 1998; Wintle, Bekessy, Pearce, Veneir, & Chisholm, 2005). Predictions of population models must be treated with caution as most population models require numerous assumptions and are themselves subject to substantial uncertainty. Despite the prevalence of uncertainty, modeling may be useful in challenging stakeholders and managers to clearly state their belief about species population dynamics and the magnitude and mechanisms of anthropogenic impacts. Models represent testable hypotheses that may be improved and updated as new data or knowledge comes to hand. As data are gathered, updated models may begin to provide predictions that are more broadly trusted by managers and stakeholders. In data-poor situations, it is important to make the most of available expertise or "collateral" data.

Bayesian approaches to inference

It is not easy or cheap to collect ecological data and definitive results are rare. Bayesian inference provides a coherent approach to synthesizing and making the most of disparate ecological data and/or expert opinion. McCarthy (2007 and summarized in Wintle, this issue) utilized a novel Bayesian approach to estimate the mortality rate of powerful owls (*Ninox strenua*) by combining very sparse observation data with predictions from a regression of body mass on mortality rate data for a range of other raptors. This approach provides a sound template for

analyses of other species that are characteristically difficult to study, including marine mammals. Expert opinion can (and should) be used in ecological studies, however it is very important that it is integrated in analyses appropriately (see Martin, Kuhnert, Mengersen, & Possingham, 2005 and McCarthy, 2007 on soliciting subjective priors for Bayesian estimates).

Once parameters have been estimated, population models may then be used to evaluate the long-term population consequences of competing management options (Akçakaya, Radeloff, Mladenoff, & He, 2004; Wintle, Bekessy, Pearce, Veneir, & Chisholm, 2005). However, any predictions arising from such a model would, at first, be compromised by substantial uncertainty in the parameter estimates. To address this, sensitivity analyses should be undertaken to identify the parameters and assumptions in the model that most strongly affect its predictions. These assumptions should then become the focus for adaptive management plans for learning.

Conclusions

It is clear that the debate surrounding physiological stress responses, behavior, welfare and anthropogenic noise are going to continue for some time. To provide some focus we offer the following points as particularly noteworthy findings and recommend that scientists and managers take them into consideration when planning research and in assessments of environmental impact of noise.

1. Noise can act as a stressor. A single source of noise can result in a range of interwoven stressors. The various potential impacts of signal masking by noise illustrate this. The cascade of interwoven stressors that can be triggered by noise and masking includes separation anxiety, anxiety arising from ambiguous information, and hypoglycemia from loss of foraging opportunities, which can all in turn lead to other consequences as discussed earlier. Even when the noise itself may not lead directly to effects arising from the stress response, animals may create their own stressors through maladaptive efforts to avoid the noise. Similarly, physical injuries resulting from noise exposure may also act as additional stressors.

2. Short-term stress responses cannot be presumed to have only short-term consequences, especially when considering cumulative effects.

3. There is great potential for synergistic effects to arise through exposure of an animal to noise cumulatively with other stressors.

4. Context, especially the predictability of the stimulus and available response choices, is a very important (and possibly the most important) factor in mediating the overall stress response. For example, very young animals and fetuses are likely to be particularly susceptible to stressors, due to the effects of stress hormones on the developing brain. Thus, while

single or infrequent exposures alone may not produce long-term effects in adults, they may produce long-term consequences in young, still-developing animals. Unfortunately, such impacts will be very hard to detect in wild animals, especially in species that are hard to observe constantly, such as marine mammals.

5. It is impossible to determine the physiological and psychological responses of an animal to a stressor based on behavioral observations alone. Changes in an individual animal's behavior (or lack thereof) cannot be related to actual physiological and psychological impact without extensive investigation of the context. Behavioral changes in context are best understood and controlled in captive situations where exposure rates, environmental conditions and other factors are documented over long periods of time. However, the extrapolation of results from captive animals to the responses of wild animals should be done very cautiously given the large contextual differences (i.e., captivity and training vs. wild and free ranging) and the potential for high ambient noise levels to alter the baseline in the captive environment. Such contextual information is not generally available when assessing the possible correlations between acoustic stimuli and behavioral change in the wild. Collecting this information presents a considerable challenge, especially in the marine environment, although it is not impossible. Impact assessment studies need to specifically incorporate long-term and large-scale contextual information in their experimental design. Current short-term studies are generally failing to correctly assess the impacts of noise. Studies that have incorporated contextual information have led to a better understanding of disturbance impacts in other human-wildlife interactions. Without such contextual information it cannot be assumed that lack of a behavioral response means that no physiological stress response has occurred, or conversely that a behavioral response indicates the occurrence of a physiological stress response. In the latter case there may still be negative consequences for the animal if the behavioral response is maladaptive, involves a detrimental increase in energetic expenditure or exposes it to other threats.

6. By definition, acclimation requires consistency between non-severe repetitive exposures (including context) to sounds that are (near-) identical as perceived by the receiver. Conversely, repetitive exposure to different types of sounds (in frequency, intensity and other acoustic characteristics) cannot result in acclimation. Furthermore, animals cannot and will never acclimate to (contextually) severe stressors as these always, by definition, represent a threat. These reasons probably explain why few studies have shown acclimation occurring in the wild. Therefore, it should be assumed that animals have not acclimated to a sound, until proven otherwise. Although humans might be able to "tune out" more generalized noise sources such as road noise, health effects of exposure to such noise can

still arise (see Clark & Stansfeld, this issue). Tuning out can have its own detrimental consequences as individuals may over-generalize that ability to other sources, which may result in that individual ignoring sounds that are important to them, such as those produced by a predator.

7. While physiological acclimation to noise in the wild appears likely to be uncommon, it is clear that many animals have the capacity to learn to react behaviorally in a specific way to a generalized set of sounds. For instance, a whale might learn not to react behaviorally to noise from all types of engines because they are have proven to be non-threatening to date. As the specific repeated experience required to induce physiological acclimation has not occurred, the whale may still initiate a stress-response to the sounds of a passing ship, priming the animal to react in the case that this particular noise is different. To date, however, the evidence that non-human animals have genuinely learned to reduce or eliminate behavioral responses to human disturbance is largely anecdotal. Regardless, generalized learning may also explain similar reductions in behavioral responsiveness to a given stressor at the population level. However, it is difficult to separate the action of such learning from a number of other possible mechanisms, including the mortality or displacement of the most susceptible individuals, gradual changes in the context in which a population find itself, and selection for adaptive responses occurring over several generations.

8. The considerable effects of relatively short periods of noise in the lab must be taken into consideration when interpreting the results of experiments undertaken with animals in captivity (see Baldwin, this issue). Most animals in captivity will have been exposed to relatively high levels of noise on a regular basis, due to feeding or other husbandry activities, machinery noise or other general facility operations. These effects, in addition to the increased sensitivity of developing brains to the effects of GCs, may partially explain why attempts to breed some animal species in captivity have not been successful.

9. Epidemiological studies in humans have been more consistent in demonstrating effects of noise on health and psychological wellbeing than on the physiological stress response. This might be explained if the epidemiological effects arise from cumulative effects over a long timeframe. Also, inconsistencies in the studies of the human physiological stress response to noise exposure may be due to (unknown) contextual elements that have not been accounted for.

10. Managing the impacts of noise on animal populations is likely to require an adaptive strategy to address the substantial uncertainties arising from a poorly understood stressor, especially in data-poor species such as many marine mammals. In situations of severe uncertainty, models can be useful

decision tools, not only because they make assumptions explicit, but also as they allow the stakeholders to explore the importance of those various assumptions. Adaptive management of noise impacts should be accompanied by well-planned long-term studies that address key uncertainties about the population level impacts of noise on the species concerned. Careful extrapolation of data from other species using appropriate analytical methods may provide a basis for developing actions to reduce noise impacts. Such actions would be refined as better, species-specific data come to hand.

References

Akçakaya, H. R., Radeloff, V.C., Mladenoff, D.J. & He, H. S. (2004). Integrating landscape and metapopulation modeling approaches: Viability of the sharp-tailed grouse in a dynamic landscape. *Conservation Biology*, **18**, 536-527.

Baldwin, A. L. (2007). Effects of noise on rodent physiology. *International Journal of Comparative Psychology*, **this issue**, 134-144.

Baldwin, A. L., Primeau, R. & Johnson, W. (2006). Effect of noise on the morphology of the intestinal mucosa in laboratory rats. *Journal of the American Association for Laboratory Animal Science*, **45**(1), 74-82.

Bateson, M. & Matheson, S. M. (2007). Removal of environmental enrichment induces 'pessimism' in captive European starlings (*Sturnus vulgaris*). *Animal Welfare*, **16**(S), 33-36.

Bateson, M. (2007). Environmental noise and decision making: possible implications of increases in anthropogenic noise for information processing in marine mammals. *International Journal of Comparative Psychology*, **this issue**, 169-178.

Beale, C. M. & Monaghan, P. (2004). Behavioural responses to human disturbance: A matter of choice? *Animal Behaviour*, **68**, 1065-1069.

Beale, C. M. (2007). The behavioral ecology of disturbance responses. *International Journal of Comparative Psychology*, **this issue**, 111-120.

Bejder, L., Samuels, A., Whitehead, H. & Gales, N. (2006a). Interpreting short-term behavioural responses to disturbance within a longitudinal perspective. *Animal Behaviour*, **72**, 1149-1158.

Bejder, L., Samuels, A., Whitehead, H., Gales, N., Mann, J., Connor, R., Heithaus, M., Watson-Capps, J. & Flaherty, C. (2006). Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology*, **20**, 1791-1798.

Black, P. (2002). Stress and the inflammatory response: A review of neurogenic inflammation. *Brain, Behavior & Immunity*, **16**(6), 622-653.

Black, P. (2003). The inflammatory response is an integral part of the stress response: Implications for atherosclerosis, insulin resistance, type II diabetes and metabolic syndrome X. *Brain, Behavior & Immunity*, **17**(5), 350-364.

Caraco, T., Blanckenhorn, W. U., Gregory, G. M., Newman, J. A., Recer, G. M. & Zwicker, S. M. (1990). Risk-sensitivity: Ambient temperature affects foraging choice. *Animal Behaviour*, **39**(2), 338-345.

Catchpole, C. K. & Slater, P. J. (1995). *Bird Song: Biological Themes and Variations*. Cambridge: Cambridge University Press. 256 pp.

Clark, C. & Stansfeld, S. A. (2007). The effect of transportation noise on health & cognitive development: A review of recent evidence. *International Journal of Comparative Psychology*, **this issue**, 145-158.

Clough, G. (1982). Environmental effects on animals used in biomedical research. *Biological Reviews*, **57**(3), 487-523.

Dallman, M. F. & Bhatnagar, S. (2001). Chronic stress and energy balance: Role of the hypothalamo-pituitary-adrenal axis. In B. S. McEwen and H. M. Goodman (Eds.), *Handbook of Physiology; Section 7: The Endocrine System; Volume IV: Coping with the Environment: Neural and Endocrine Mechanisms* (pp. 179-210). New York: Oxford University Press.

Deak, T. (2007). From classic aspects of the stress response to neuroinflammation and sickness: Implications for individuals and offspring of diverse species. *International Journal of Comparative Psychology*, **this issue**, 96-110.

Deak, T., Bordner, K. A., McElderry, N. K., Bellamy, C., Barnum, C. J. & Blandino Jr, P. (2005). Stress-induced increases in hypothalamic il-1: A systematic comparison of multiple stressor paradigms. *Brain Research Bulletin*, **64**(6), 541-556.

Dhabhar, F. S. & McEwen, B. S. (1997). Acute stress enhances while chronic stress suppresses cell mediated immunity in vivo: A potential role for leukocyte trafficking. *Brain, Behavior & Immunity*, **11**, 286-306.

Fuller, R. A., Warren, P. H. & Gaston, K. J. (2007). Daytime noise predicts nocturnal singing in urban robins. *Biology Letters*, **3**(4), 368-370. (doi: 10.1098/rsbl.2007.0134).

Gill, J. A., Norris, K. & Sutherland, W. J. (2001). Why behavioural responses may not reflect the population consequences of human disturbance. *Biological Conservation*, **97**, 265-268.

Green, W. H., Campbell, M. & David, R. (1984). Psychosocial dwarfism: A critical review of the evidence. *Journal of the American Academy of Child Psychiatry*, **23**, 39-48.

Harrington, F. H. & Veitch, A. M. (1992). Calving success of woodland caribou exposed to low-level jet fighter overflights. *Arctic*, **45**, 213-218.

Hatch, L. & Wright, A. J. (2007). A brief review of anthropogenic sound in the oceans. *International Journal of Comparative Psychology*, **this issue**, 121-133.

Homan, G. F., Davies, M. & Norman, R. (2007). The impact of lifestyle factors on reproductive performance in the general population and those undergoing infertility treatment: A review. *Human Reproduction Update*, **13**(3), 209-223.

Hontela, A., Rasmussen, J. B., Audet, C. & Chevalier, G. (1992). Impaired cortisol stress response in fish from environments polluted by PAHs, PCBs, and mercury. *Archives of Environmental Contamination and Toxicology*, **22**, 278-283

Jaquet, N. (2000). Simple photogrammetric technique to measure sperm whales at sea. *Marine Mammal Science*, **22**(4), 862–879.

Kapoor, A., Dunn, E., Kostaki, A., Andrews, M. H. & Matthews, S. G. (2006). Fetal programming of hypothalamo-pituitary-adrenal function: Prenatal stress and glucocorticoids. *The Journal of Physiology*, **572**(1), 31–44.

Levine, S., Goldman, L. & Coover, G. D. (1972). Expectancy and the pituitary-adrenal system. *Ciba Foundation Symposium*, **8**, 281-291.

Lusseau, D. (2004). The hidden cost of tourism: Detecting long-term effects of tourism using behavioural information. *Ecology and Society*, **9**(1), 2. Retrieved 12 September 2007, from http://www.ecologyandsociety.org/vol9/iss1/art2

Lusseau, D. (2005). The residency pattern of bottlenose dolphins (*Tursiops spp*.) in Milford Sound, New Zealand, is related to boat traffic. *Marine Ecology Progress Series*, **295**, 265-272.

Lynch, C.W. & Risotto, S.P. (1985). *Gulf of Mexico Summary Report, October 1984 - June 1985: Outer Continental Shelf Oil and Gas Activities in the Gulf of Mexico and Their Onshore Impacts*. Vienna, VA: U.S. Department of the Interior, Minerals Management Service, Outer Continental Shelf Oil and Gas Information Program, OCS Information Report OCS/MMS-85-0083. 108 pp.

Martin, T. G., Kuhnert, P. M., Mengersen, K. & Possingham., H. P. (2005). The power of expert opinion in ecological models using Bayesian methods: impact of grazing on birds. *Ecological Applications*, **15**, 266-280.

Martineau, D. (2007). Potential synergism between stress and contaminants in free-ranging cetaceans. *International Journal of Comparative Psychology*, **this issue**, 194-216.

Matheson, S. M., Asher, L. & Bateson, M. (2008). Larger, enriched cages are associated with 'optimistic' response biases in captive European starlings (*Sturnus vulgaris*). *Applied Animal Behavior Science*, **109**, 374-383.

McCarthy, M. A. (2007). *Bayesian Methods for Ecology*. Cambridge: Cambridge University Press.

Melancon, J. M., Bongiovanni, R. & Baud, R. D. (2003). *Gulf of Mexico Outer Continental Shelf Daily Oil and Gas Production Rate Projections From 2002 Through 2006*. New Orleans, LA: U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, OCS Report MMS 2003-028. 17 p. Available at: http://www.gomr.mms.gov/PDFs/2003/2003-028.pdf

NMFS – U.S. National Marine Fisheries Service (1996). *Environmental Assessment on Conditions for Lethal Removal of California Sea Lions at the Ballard Locks to Protect Winter Steelhead*. NMFS Environmental Assessment Report. Seattle WA: Northwest Regional Office, NMFS, U.S. National Oceanic and Atmospheric Administration. 81 pp.

Noad, M. J., Cato, D. H., Bryden, M. M., Jenner, M.–N. & Jenner, K. C. S. (2000). Cultural revolution in whale songs. *Nature*, **408**, 537.

Payne, K., Tyack, P. & Payne, R. (1983). Progressive changes in the song of humpback whales (*Megaptera novaeangliae*): a detailed analysis of two seasons in Hawaii. In: R. Payne (Ed.), *Communication and Behavior of Whales* (pp. 9-57). Boulder, Colorado: Westview Press.

Romero, L. M. & Butler, L. K. (2007). Endocrinology of stress. *International Journal of Comparative Psychology*, **this issue**, 89-95.

Romero, L. M. (2004). Physiological stress in ecology: Lessons from biomedical research. *Trends in ecology and evolution*, **19**, 249-255.

Sapolsky, R. M. (1992). *Stress, the Aging Brain, and the Mechanisms of Neuron Death*. Cambridge, MA: MIT Press.

Sapolsky, R. M., Romero, L. M. & Munck, A. U. (2000). How do glucocorticoids influence stress-responses? Integrating permissive, suppressive, stimulatory, and adaptive actions. *Endocrine Reviews*, **21**, 55-89.

Scheifele, P. M., Andrew, S., Cooper, R. A., Darre, M., Musiek, F. E. & Max, L. (2005). Indication of a Lombard vocal response in the St. Lawrence River beluga. *Journal of the Acoustical Society of America*, **117**(3), 1486-1492.

Schiml-Webb, P. A., Deak, T., Greenlee, T. M., Maken, D. & Hennessy, M. B. (2006). Alpha-melanocyte stimulating hormone reduces putative stress-induced sickness behaviors in isolated guinea pig pups. *Behavioural Brain Research*, **168**(2), 326-330.

Stansfeld, S. A., Haines, M. M. & Brown, B. (2000). Noise and Health in the Urban Environment. *Reviews on Environmental Health*, **15**, 43-82.

Stillman, R. A. & Goss-Custard, J. D. (2002). Seasonal changes in the response of oystercatchers *Haematopus ostralegus* to human disturbance. *Journal of Avian Biology*, **33**, 358-365.

Tarnopolsky, A., Barker, S. M., Wiggins, R. D. & McLean, E. K. (1978). The effect of aircraft noise on the mental health of a community sample: A pilot study. *Psychological Medicine*, **8**, 219-233.

Taylor, M. & Plater, B. (2001). *Population Viability Analysis for the Southern Resident Population of the Killer Whale (*Orcinus orca*)*. Tucson, Arizona, USA: The Center for Biological Diversity.

Todd, S., Stevick, P., Lien, J., Marques, F. & Ketten, D. (1996). Behavioural effects to underwater explosions in humpback whales (*Megaptera novaeangliae*). *Canadian Journal of Zoology*, **74**, 1661-1672.

Ulrich-Lai, Y. M., Figueiredo, H. F., Ostrander, M. M., Choi, D. C., Engeland, W. C. & Herman, J. P. (2006). Chronic stress induces adrenal hyperplasia and hypertrophy in a subregion-specific manner. *American Journal of Physiology – Endocrinology and Metabolism*, **291**(5), E965-E973. (doi:10.1152/ajpendo.00070.2006).

Wade, P. R. (1998). Calculating limits to the allowable human caused mortality of cetaceans and pinnipeds. *Marine Mammal Science*, **14**(1), 1-37.

Watwood, S. L., Owen, E. C. G., Tyack, P. L. & Wells, R. S. (2005). Signature whistle use by temporarily restrained and free-swimming bottlenose dolphins, *Tursiops truncatus*. *Animal Behaviour*, **69**(6), 1373-1386.

Wilhere, G. F. (2002). Adaptive management in habitat conservation plans. *Conservation Biology*, **16**, 20–29.

Wintle, B. A. (2007). Adaptive management, population modelling and uncertainty analysis for assessing the impacts of noise on cetacean populations. *International Journal of Comparative Psychology*, **this issue**, 237-250.

Wintle, B. A., Bekessy, S. A., Pearce, J. L., Veneir, L. A. & Chisholm, R. A. (2005). Utility of dynamic landscape metapopulation models for sustainable forest management. *Conservation Biology*, **19**, 1930-1943.

Wischmann, T. H. (2003). Psychogenic infertility: Myths and facts. *Journal of Assisted Reproduction and Genetics*, **20**(12), 485-494.

Wright, A. J. & Kuczaj, S. (2007). Noise-related stress and marine mammals: an introduction. International Journal of Comparative Psychology, **this issue**, iii-viii.

Wright, A. J., Aguilar, Soto, N., Baldwin, A. L., Bateson, M., Beale, C., Clark, C. et al. (2007b). Do marine mammals experience stress related to anthropogenic noise? *International Journal of Comparative Psychology*, **this issue**, 274-316.

International Journal of Comparative Psychology, 2007, **20**, 274-316.
Copyright 2007 by the International Society for Comparative Psychology

Do Marine Mammals Experience Stress Related to Anthropogenic Noise?

Andrew J. Wright
Leviathan Sciences, U.S.A.

Natacha Aguilar Soto
La Laguna University, Spain

Ann Linda Baldwin
University of Arizona, U.S.A

Melissa Bateson
Newcastle University, United Kingdom

Colin M. Beale
Macaulay Institute, United Kingdom

Charlotte Clark
Queen Mary, University of London, United Kingdom

Terrence Deak
State University of New York at Binghamton, U.S.A.

Elizabeth F. Edwards
Southwest Fisheries Science Center U.S.A.

Antonio Fernández and Ana Godinho
University of Las Palmas de Gran Canaria, Spain

Leila T. Hatch
Gerry E. Studds Stellwagen Bank National Marine Sanctuary U.S. National Oceanic and Atmospheric Administration, U.S.A.

Antje Kakuschke
GKSS Research Centre, Institute for Coastal Research, Germany

David Lusseau
Dalhousie University, Canada University of Aberdeen, United Kingdom

Daniel Martineau
University of Montreal, Canada

L. Michael Romero
Tufts University, U.S.A.

Linda S. Weilgart
Dalhousie University, Canada

Brendan A. Wintle
University of Melbourne, Australia

Giuseppe Notarbartolo-di-Sciara
Tethys Research Institute, Italy

Vidal Martin
Society for the Study of Cetaceans in the Canary Archipelago (SECAC) / Canary Island Cetacean Museum, Spain

This paper could not have been written without the financial and organizational support from Dieter Paulmann and Jo Hastie respectively. Thanks are also due to two anonymous reviewers, whose comments on an earlier version of the manuscript greatly improved the paper. The views expressed in this paper are those of the authors alone and do not represent those of Stellwagen Bank National Marine Sanctuary, the U.S. National Marine Sanctuary Program, Southwest Fisheries Science Center, the U.S. National Marine Fisheries Service, NOAA and/or any other institution or agency. Correspondence concerning this article should be addressed to Andrew Wright, Leviathan Sciences, U.S.A. (marinebrit@gmail.com).

Sound travels much further than light in the marine environment. As a result, marine mammals, especially cetaceans, rely heavily on sound for many important life functions, including breeding and foraging. This reliance on sound means it is quite likely that exposure to noise will have some detrimental effects on these life functions. However, there has been little application to marine mammals of the knowledge available in other species of stress responses to noise and other stressors. In this paper we begin to integrate what is known about marine mammals with the current knowledge gained in terrestrial mammals about stress physiology, specifically considering physiological and psychological context and thus also cumulative and synergistic impacts. We determined that it is reasonable to extrapolate information regarding stress responses in other species to marine mammals, because these responses are highly conserved among all species in which they have been examined to date. As a result, we determined that noise acts as a stressor to marine mammals. Furthermore, given that marine mammals will likely respond in a manner consistent with other species studied, repeated and prolonged exposures to stressors (including or induced by noise) will be problematic for marine mammals of all ages. A range of issues may arise from the extended stress response including, but not limited to, suppression of reproduction (physiologically and behaviorally), accelerated aging and sickness-like symptoms. We also determined that interpretation of a reduction in behavioral responses to noise as acclimation will be a mistake in many situations, as alternative reasons for the observed results are much more likely. We recommend that research be conducted on both stress responses and life-history consequences of noise exposure in marine mammals, while emphasizing that very careful study designs will be required. We also recommend that managers incorporate the findings presented here in decisions regarding activities that expose marine mammals to noise. In particular, the effects of cumulative and synergistic responses to stressors can be very important and should not be dismissed lightly.

As sound travels much better than light in the ocean (Urick, 1983) many marine animals, including marine mammals, use sound instead of light to gain information about their environment (Popper, 2003; Richardson, Greene, Malme & Thomson, 1995; Tyack & Miller, 2002). Cetaceans (whales, dolphins and porpoises) in particular are heavily dependent on sound to find food, communicate (including for reproduction), detect predators and navigate. Increasing mechanized use of the sea, such as for shipping, military activities, oil and gas exploration, and recreation (including cruises and pleasure boating), is increasing the amount of noise that humans introduce into the oceans, sometimes over very large distances (for details and discussion, see Hatch & Wright, this issue).

As cetaceans (as well as other marine mammals) are primarily acoustic animals, it appears likely that they will suffer more from exposure to noise than other species, including rats and humans - both species for which there is some information available about the consequences of noise exposure. It is reasonable to assume that marine mammals' reliance on sound has led to the evolution of a number of adaptive mechanisms to deal with natural noise, but whether those mechanisms are sufficient to compensate for the comparatively recent advent of anthropogenic ocean noise is uncertain (see Bateson, this issue; Weilgart, this issue). For example, cetaceans may have developed various strategies that are better than those employed by terrestrial species at averting or handling the problems created by masking (i.e., the drowning out of a signal of interest by noise). Regardless, their ability to cope with noise will still have limits. Indeed, anthropogenic underwater noise is a novel environmental element for marine mammals and some species have been exposed to it for only one generation (e.g., bowhead whale, *Balaena mysticetus*). This is a very short period in terms of

evolutionary time, making it very unlikely that any marine mammals have developed appropriate coping mechanisms (Rabin & Greene, 2002).

Here we attempt to increase our understanding of the effects of sound on marine mammals through the application of the current state of knowledge about noise, physiological stress and the influence of context, as outlined in Wright et al. (this issue, a) and detailed further in the other papers in this issue. Wright et al. (this issue, a) and the references therein should thus be considered the source for information included in this document unless other sources are cited. Working definitions for the terminology related to 'stress' are provided by Wright & Kuczaj (this issue).

Review of known effects of noise in marine mammals

Marine mammals have demonstrated various responses to specific noise exposures ranging from changes in their vocalizations (shifts in frequency, becoming silent, etc.) and displacement or avoidance (including shifting their migration paths) through alterations in their diving, swim speed, respiration or foraging behavior, to hearing damage and strandings (see Appendix 1). Weilgart (this issue) provides a summary of the known effects and the references therein offer additional details.

Hearing damage is not discussed here, as this is not a result of a noise-induced stress response. However, it should be noted that ear damage and other physical injuries would, if not immediately fatal, act as a variety of stimuli/stressors in their own right, each with the potential for producing a stress response. Thus, sound may generate both auditorily-mediated (i.e., heard) stimuli/stressors and non-auditory (i.e., those not directly resulting from sound perception through the ear) stimuli/stressors.

Noise and Stress in Marine Mammals

Two studies to date have investigated the physiological stress response to noise in captive marine mammals. Thomas, Kastelein & Awbrey (1990) exposed four captive beluga whales (*Delphinapterus leucas*) to playbacks of drilling noise but found no changes in blood adrenaline and norarenaline ("stress hormones", also known as epinephrine and norepinephrine) levels measured immediately after playbacks. Romano et al. (2004) exposed captive bottlenose dolphins (*Tursiops truncatus*) and a beluga whale to sounds from a seismic water gun and (for the bottlenose dolphins only) 1 s, 3 kHz pure tones and observed detrimental changes in some of the various hormones in the blood (for more details, also see Weilgart, this issue). However, the small sample sizes of these studies, their use of captive animals and other technical limitations mean that extrapolation of their results to wild animals should be done with caution (as recommended by Thomas, Kastelein & Awbrey, 1990). Additionally, there may have been some level of response to background noise levels that were not accounted for in the baseline measurements (see Baldwin, this issue).

It should also be noted that the epidemiological studies undertaken in humans examining physiological effects such as hypertension and coronary heart disease have been more consistent and conclusive than those considering the various stress hormones (see Clark & Stansfeld, this issue). Accordingly, it appears to be possible for noise to cause effects consistent with prolonged exposure to a stressor, such as hypertension and coronary heart disease, without necessarily displaying a consistent increase in stress hormones, such as glucocorticoids (GCs), and other metrics.

Three specific examples of the effects of sound on marine mammals are considered here in greater detail: the stranding of beaked whales (*Ziphiidae*) in association with military sonar exercises; the effects of shipping noise on beaked whale foraging and communication; and the various effects on the energy budget of odontocetes (toothed cetaceans) from disturbance due to whalewatching activities. Disruptions caused by whalewatching are likely to result from a combination of the actual presence of the whalewatching vessels as well as their noise. However, the effects of whalewatching and those of noise from moderately distant shipping are similar in many respects (see Lusseau & Bejder, this issue; Weilgart, this issue), suggesting that noise is probably the predominant source of impact of whalewatching. Furthermore, playback experiments have demonstrated that vessel noise alone can elicit responses in at least some species (e.g., manatees, *Trichechus manatus*: Miksis-Olds, Donaghay, Miller, Tyack & Reynolds, 2007).

Beaked whale strandings

Beaked whales have repeatedly mass-stranded a few hours to days after naval maneuvers during which military ships used midrange frequency sonar (Fernandez et al., 2005; Hildebrand, 2005)[1]. These whales were consistently affected by a new syndrome, never described in marine mammals prior to these events, consisting of extensive fat and gas bubble emboli: an ensemble of lesions most similar to decompression sickness in human divers (Fernández et al., 2005; Jepson et al., 2003). It is clear that the severity of emboli is the direct cause of death and that the constant temporal and spatial coincidence with naval exercises involving sonar designates these exercises as the cause of this new syndrome (Fernandez et al., 2005; Hildebrand, 2005). Recent studies have qualified beaked whales as the deepest diving mammals (down to 1.8 km: Tyack, Johnson, Aguilar Soto, Sturlese & Madsen, 2006) and have shown that these animals typically

[1] With regards to the debate over the frequency of strandings coincident with such activities, it should be noted that the discovery of just one dead body from a wild population is widely accepted in terrestrial biology to be always indicative of a wider problem, as it is easy to miss carcasses (p14-15 in Wobeser, 1994). This is likely to be even more true with marine mammals, where dead animals can be quickly scavenged upon, carried away by strong currents, or sink beneath the waves if they float at all. Deep diving marine mammals, such as beaked whales, that die at depth may be prevented from rising to the surface at all due to inhibition of decay-induced floating by the increased hydrostatic pressure (Allison, Smith, Kukert, Deming & Bennett, 1991). There are also fewer potential observers that are much more widely scattered than in terrestrial environments.

(although not always) follow a highly stereotyped diving pattern. This pattern consists of a deep dive followed by progressively shallower dives, apparently similar to the decompression stops used by human divers to avoid decompression sickness, although this is not necessarily their function (Tyack et al., 2006). Tyack et al. (2006) instead argued that the collapse of the whales' lungs at depth alleviates the need for such decompression dives.

In either case, behavioral disturbances, such as a startle or flight response, that disturb this highly stereotyped diving pattern, may overwhelm or circumvent the normal nitrogen buffering physiology of beaked whales and trigger the formation of nitrogen bubbles (i.e., 'the bends'), with the ultimate outcome being death from gas embolism and/or hemorrhage (see Cox et al., 2006; Tyack et al., 2006). While this remains the predominant theory, the physiological processes by which it occurs are still unknown (Cox et al., 2006) and other causes of death have also been suggested (see review by Rommel et al., 2006). For example, it has been hypothesized that instead of or in addition to indirect action via behavior disturbance, the navy maneuvers may directly induce the formation of nitrogen bubbles through a process termed "rectified diffusion" (Crum & Mao, 1996; Houser, Howard & Ridgway, 2001).

Additional support for the flight hypothesis is found in the similar response to novel sounds observed in other cetacean species. For example, Nowacek, Johnson & Tyack (2004) exposed foraging North Atlantic right whales (*Eubalaena glacialis*) tagged with a Digital Acoustic Recording Tag (DTag: Johnson & Tyack, 2003) to vessel noise, whale social sounds, silence, and a synthetic signal designed to alert the whales to the presence of vessels and thus reduce ship-strikes. Five out of six whales exposed to the alert signal responded by abandoning their foraging dive prematurely and executing a shallow-angled, high power (i.e., significantly increased fluke stroke rate) ascent and continued to swim at shallow depths, surfacing only to breathe, for the duration of the exposure: an abnormally long surface interval. This response was elicited by alarm sounds at received levels as low as 133 to 148 dB re 1 μPa at 1000 Hz. None of the whales exposed to ship noise playbacks responded at all.

There is also some indication that a stress response may be at least partly involved in reactions of beaked whales to military exercises involving sonar. Intracellular globules composed of acute phase protein have been found in the cells of six out of eight livers examined from beaked whales stranded in association with such exercises (tissue decay prevented detailed examination in nine others; Godinho/Fernandez, unpublished data). The globules are also found in the cytoplasm of hepatocytes in a range of examined cetacean species that stranded for many different reasons, including animals that are known to have died in 'very stressing' circumstances (e.g., anthropogenic interactions, such as bycatch; pathologies; or heat shock; Godinho et al., 2005). For example, globules have been seen in 26 of the 27 livers examined from bycaught harbor porpoises (*Phocoena phocoena*) in one study, with the only negative result being a neonate, possibly because of its immature metabolism (Godinho et al., 2006). Furthermore, only 7 of the other 11 examined porpoises that stranded for other or unknown reasons were

positive (Godinho et al., 2007; Godinho, unpublished data). It is acknowledged that live stranding itself is also likely to be an intense stressor.

The mechanism for the accumulation of acute phase proteins and the function that they have in the organism are not clear and there are various theories. For example, one hypothesis is that the vascular compromise (e.g., resulting from live-stranding) leads to acute liver congestion, which has been observed in 17 different cetacean species, that could in turn prevent the proteins from leaving the cell, where they thus accumulate and the globules are formed (Godinho et al., 2005; Godinho/Fernandez, unpublished data). However, for reasons not yet known, the globules in the above study vary both within and between species, as shown by electron microscopy and inmumohistochemistry (Godinho et al., 2007).

Hypoxia may also become a compounding issue for any marine mammal exposed to a stressor at depth, because oxygen consumption increases dramatically with increased heart rate as a result of release of catecholamines (adrenalin/epinephrine and noradrenalin/norepinephrine) through activation of the sympathetic nervous system (SNS: see Deak, this issue, Romero & Butler, this issue). The increase in heart rate is usually associated with a corresponding increase in respiration; however this is not possible at depth. This additional oxygen demand during pronounced SNS activation could therefore be particularly problematic for deep divers that are already living right on the physiological edge. Beaked whales are thought to be diving beyond their aerobic limits (Tyack et al., 2006; Aguilar Soto et al., 2006) so additional oxygen demands could force them to cut their dives short. Regardless, the combination of a psychological stressor (extreme noise that is perceived as threatening) with a more direct physiological stressor (fat and gas emboli or hypoxia) may have some potentially deleterious consequences (see Deak, this issue). Such a combination may have contributed to beaked whale deaths recorded in the mass strandings or unobserved at sea, as well as negatively affecting the health and fecundity of survivors of the events.

Although it is possible that a stress response contributed directly in some way to the lethal consequences resulting from exposure of beaked whales to military exercises involving sonar, it remains most likely that the fatalities resulted from the whales' flight response. In understanding this subtle difference, it is useful to consider the three successive stages of adaptation to insult (i.e., a stressor) presented by Selye (1946): alarm reaction; stage of resistance; and stage of exhaustion. An animal may respond at the very initial stages of a stress response (alarm) by fleeing (i.e., flight arising from the SNS response). If this action removes the animal from exposure to the stimulus then it may only lead to a short GC response (resistance), if any at all (see Deak this issue, Romero & Butler, this issue). However, if the flight response is lethally mal-adaptive, as appears to be the case with beaked whales and military sonar exercises, the exposure may still result in death, just not as a consequence of 'stress' *per se* (as in 'chronic stress' – exhaustion). It might also be possible that flight responses are increased if a stimulus is not only psychological, but also noxious (i.e., painful) by the direct effect of the noise pressure on the tissues and/or ear.

Shipping and masking of signals of importance for cetaceans

Shipping is most likely the main overall source of man-made noise in the marine environment (NRC, 1994, 2003) and masking has been identified as the primary auditory effect of vessel noise on marine animals (Southall, 2005). Most concern on this subject has traditionally focused on mysticetes (baleen whales), which communicate at the low frequencies typically associated with shipping noise (e.g., Payne & Webb, 1971). Consequently, it is noteworthy that ambient noise levels in the deep ocean at low frequencies have increased by 10-15 dB over the past 50 years due to motorized shipping (see Hatch & Wright, this issue, a and references therein). However, there is increasing evidence that modern ship noise can reach higher frequencies (e.g., up to 30 kHz: Arveson & Venditis, 2000; up to 44.8 kHz: Aguilar Soto et al., 2006) at distances of at least 700 m (Aguilar Soto et al., 2006). For example, there is a recording of a passing vessel on a DTag attached by suction cups to a Cuvier's beaked whale (*Ziphius cavirostris*) that demonstrates clearly that ship noise can mask ultrasonic vocalizations of odontocetes (Aguilar Soto et al., 2006). The high-frequency components of shipping noise may also be increasing due to the trend toward faster ships (Southall, 2005), because broadband cavitation noise (including the higher frequencies) generally increases with vessel speed (Arveson & Venditis, 2000).

Masking predominantly results from noise at similar frequencies to the signals of interest, although there may be some masking effects from "out-of-band" frequencies. Considering only in-band masking, the measured increase of up to 15 dB in low frequency noise due to shipping will greatly reduce the maximum functional range for signals in that band (Au, 1993). Similarly, calculations made be Aguilar Soto et al. (2006) demonstrated that the maximum communication range at frequencies used by Cuvier's beaked whales would be reduced by 82% (to 18% of its normal value) when exposed to a 15 dB increase in ambient noise at these frequencies, as was observed in the above-mentioned recording of a passing vessel. They also determined that the effective detection distance of echolocation clicks would also be reduced by 58% (to 42% of their normal range). Furthermore, if the current trend observed at low frequencies were applied to the higher frequencies component of ship noise, leading to a further increase of 15 dB by 2050, beaked whale communication at those frequencies would be reduced by 97% (to only 3 % of their 1950 maximum range) with each passing vessel (Aguilar Soto et al., 2006).

It is important to note that these calculations are based on observed increases in noise at high frequencies from a single passing vessel, that noise profiles from ships are highly variable and that high frequency noise attenuates much more rapidly than low frequency noise (see Hatch & Wright, this issue), limiting the area over which Cuvier's beaked whales would be affected. However, the trend towards faster boats, producing more cavitation and thus noise at higher frequencies, should also be considered. Furthermore, marine mammals that predominantly use low frequencies (e.g., baleen whales) may suffer similar reductions in the effective range of communication and other signals over much larger areas with additional reductions nearer a passing vessel. At the very low

frequencies used by many mysticetes (e.g., under 200 Hz), masking may occur in the majority of the oceans, especially in the northern hemisphere (see Hatch & Wright, this issue). Consequently, it would not be possible for these species to employ an avoidance strategy (see Bateson, this issue; Wright et al, this issue, a) because of the omnipresence of increased background noise from ships.

This reduction in effective distances for communication will almost certainly be associated with an increase in the ambiguity of information received. The reception of ambiguous signals can act as a stressor and/or potentially lead to consequences such as missed mating opportunities and unidentified predators (see Bateson, this issue). These consequences can be especially problematic for animals that are already compromised in some way (see Wright et al., this issue, a). For example, a whale that is already in a state of chronic stress is more likely to interpret ambiguous information pessimistically and act accordingly, such as not chasing as many possible prey items or wasting energy avoiding more possible predators.

Whalewatching and energy budgets

Interactions between boats and cetaceans are known to have a number of effects on marine mammals, although they may not even be consistent among different groups within the same species (see Lusseau & Bejder, this issue). For example, in Doubtful Sound, New Zealand, female bottlenose dolphins (*Tursiops* spp.) responded linearly to increased disturbance intensity (increased intrusiveness of boat interactions) by increasing dive duration (Lusseau 2003). Conversely, the males almost immediately adopted an avoidance strategy by substantially increasing their dive duration, but then did not increase it further with increasing interaction intrusiveness. There are a number of possible reasons for this difference between males and females, including the fact that energetic demands and consequences differ between the sexes (e.g., reproduction). Whatever the reason, it may be that the males' avoidance strategy spares them from higher noise exposure and disturbance rates, limiting their physiological stress response. Alternatively, the males may be falling into an ecological trap and the females may be better off if the physiological stress response is actually quite limited and they can still continue to forage effectively.

Although difficult, it is possible to estimate the energetic consequences of behavioral alterations and other avoidance strategies (see Lusseau and Bejder, this issue). For example, increases in time spent traveling and decreases in time foraging in northern resident killer whales (*Orcinus orca*) in response to disturbance by whalewatching traffic led not only to a relatively small (although not necessarily inconsequential) estimated increase in energetic demands of 3%, but also to a estimated reduction in energetic intake of 18% (Williams, Lusseau & Hammond, 2006). It should be noted that these are minimum estimates, as any costs associated with a stress response (physiological or psychological) or as a consequence of masking would be in addition to these figures.

Dolphins have been observed apparently shifting from short-term avoidance (local behavioral) to long-term avoidance (habitat displacement)

strategies in response to passing a threshold of disturbance from tourist boats (see Lusseau & Bejder, this issue). Presumably, at the point where this behavioral switch occurred, the dolphins determined in some way that the various costs associated with remaining in the disturbed habitat had become larger than the potential benefits. Consequently, when either habitat value is very high or habitat displacement is not an option (e.g., because boat interactions occur throughout the home range of the population), the costs of short-term avoidance strategies can accumulate and have serious implications for the population's viability. Alternatively, habitat displacement can also be very costly, as new habitats may have to be found or fought for, and knowledge of the area (e.g., prey locations) may have to be learned anew, the reduced habitat awareness potentially acting as a stressor in the meantime.

In either case, the various changes in the energy budget of an animal can, in turn, have a number of additional consequences. If the animal is still consuming more energy than it is using, it can continue to survive and grow, although unquestionably it will be less able to deal with anything that places additional energetic demands upon it, such as disease, migration and reproduction. As any remaining energetic surplus diminishes, a number of significant effects may begin to appear. For example, if the energy and resources available to a parent limits natal and/or parental investment, there will be various consequences for the health of the offspring (see Wright et al., this issue, a). Ultimately, if the animal is not able to consume enough energy to meet the increased demands, then it will begin to metabolize its lipid stores before it slowly starves to death or is forced to leave the area. In marine mammals the largest lipid store is the blubber layer, the mobilization of which will concurrently lead to an increase in contaminant levels in the blood (see Cumulative and Synergistic Effects). It should also be noted that hypoglycemia is a very powerful threat to homeostasis (i.e., a large stressor) that leads to rapid activation of stress responsive systems.

Something akin to the above may be occurring in both Shark Bay, Australia and Doubtful Sound, New Zealand. In Shark Bay a significant 15% decline in the relative abundance of dolphins was observed in an area where dolphin-watching activities occur, while a similar decline was not observed in an adjacent control site free from whalewatching activity (Bejder et al., 2006). In Doubtful Sound, the rate and frequency of perinatal deaths have significantly increased and the population abundance has decreased concurrently with a significant and substantial increase in the number of boats as well as the number of trips per boat (Lusseau, Slooten & Currey, 2006). The costs associated with boat interactions are such that females have to maintain homeostasis by reducing energetic investment in the only extrinsic factor they can manipulate: reproduction. It is not known how the males are faring in comparison.

Cumulative and Synergistic Effects

If context is important in controlling how noise induces stress responses in marine mammals and the various potential consequences thereof, it is crucial to consider the other potential stressors and anthropogenic activities that may be

influencing marine mammals at any given time. We will not go into detail about the various possible additional anthropogenic stressors here, as the U.S. Marine Mammal Commission (Reeves & Ragen, 2004) provided an effective summary of the majority of other threats to marine mammals. Its annual reports also provide more information (MMC, 2007 and previous).

The following threats will almost certainly contribute in one way or another to a reduction in the condition of individuals (i.e., an increase in the "allostatic load"), which might, among other things, make them more susceptible to other potential stressors, including noise. As mentioned above, a reduction in the overall condition can also influence the psychological outlook of an animal (see Bateson, this issue). Although acting primarily on individuals, the impacts of these stressors may filter up to the population level if they affect an individual's survival or fecundity. These threats include:

- climate change and other ecosystem-wide change;
- habitat loss or degradation through coastal and offshore development, fishery activity (including due to a reduction in available prey), inland development (that results in material washing downriver either immediately or over an extended period as a consequence of a change in land-use, such as clearing forests), etc.;
- disease;
- toxic algal blooms ; and
- contaminants (especially adrenocorticotoxic contaminants: see Martineau, this issue).

Several other threats may also induce stress responses in individual marine mammals. However, they generally result in removal of an individual from the wild (either through mortality or permanent capture). Consequently, these other threats do not usually contribute to any existing stress response an animal may be experiencing prior to an exposure to noise, but are more likely to act cumulatively with noise-related stress effects at the population level. These include:

- fisheries bycatch;
- ship strikes;
- whaling; and
- dolphin drives.

It is also possible for exposure to noise (through a stress response or other means) to make individuals more susceptible to any of the above additional threats, including the generally lethal ones. For example, Nowacek et al. (2004) concluded that the alarm stimuli mentioned previously were poor options in attempts to mitigate vessel collisions with North Atlantic right whales, since the reaction of most animals in the study likely placed them at greater risk of vessel collision. Consequently, it is very important for managers to consider this conclusion when making decisions regarding the introduction of other novel sounds into the habitat

of this highly endangered and declining species (Carretta et al., 2007), especially as the entire range for the species (the coasts of southern Canada to northern Florida) is an area that has a high concentration of shipping traffic.

Additionally, marine mammals, especially deep divers, are often thought to be pushing their physiological and anatomical limits as part of their normal behavior. They often subject themselves to considerable pressures as well as large changes in pressure on a regular basis, all while holding their breath for prolonged periods. The hypothesized anaerobic diving in beaked whales discussed above is one example of this. Another would be the bone damage seen in sperm whales (*Physeter macrocephalus*), which is thought to be a manifestation of the "bends" (Moore & Early, 2004). Such extreme conditions and related injuries could potentially be acting as additional injury stressors in their own right and might thus make marine mammals more susceptible to cumulative effects with other stressors, especially those thought to be mainly psychological in nature (see Deak, this issue).

Although information is generally lacking about how exposure to noise may ultimately affect marine mammals, it is possible to draw from the available information on how they respond to exposure to other stressors. Consequently, the following discussions examine the various effects of two of the most common threats to marine mammals: contaminant loads, with examples from pinnipeds and belugas; and interactions with fisheries, with an example from tuna-dolphin sets. These examples also provide some insight into the possible physiological and psychological condition that marine mammals might be in when exposed to noise (i.e., context), thus indicating potential pathways for cumulative interactions with noise exposure.

Contaminants

Marine mammals are especially susceptible to the effects of contaminants due to their high trophic level in the food web, long-life span, relatively late maturity and low reproductive potential. Many contaminants (or their metabolic products) bioaccumulate, meaning that they are found at increasing concentrations in the tissues of animals that occupy higher trophic positions. This process can lead to very high concentrations in long-lived adults or in newborns, when lipophilic contaminants are transferred from the mother through milk (see Martineau, this issue). This is because much of the contaminant load is stored in the blubber layer, which is partially metabolized for milk production (see Martineau, this issue). In many marine mammals, the first offspring stands to receive the highest dosage as the mother might have been bioaccumulating for many years before the first offspring is born, while only accumulating contaminant loads for a year or two in between pregnancies (Beckmen, Blake, Ylitalo, Stott & O'Hara, 2003). The blubber layer is also metabolized during periods of fasting or starvation (including times of migration, such as in mysticetes, or reproduction, such as in many pinnipeds), delivering the contaminant load to the fasting animal.

While contaminant loads compromise animals and are often associated with increased occurrences of various pathological conditions, different

contaminants can have very different effects. For example, some organochlorine compounds (OCs), such as dioxin-like polychlorinated biphenyls (PCBs), can cause apoptosis (i.e., self-destruction) of T-cells in the same way that a GC stress response does. Dioxin-like PCBs (and their metabolites) are also known to interfere with the size and effectiveness of the GC response (see Martineau, this issue). Other OCs metabolites, such as DDT's, are known to damage the adrenal cortex (see Martineau, this issue), which is also involved in the stress response.

Many substances (or groups of substances) may have a range of effects (see Kakuschke & Prange, this issue). For example, studies have linked high metal burdens with a large variety of impacts in marine mammals ranging from lower resistance to diseases, through harmful influences on the liver, kidney, central nervous system and reproductive system, to stillbirths. Metals also impair immune cell function through a number of mechanisms. Depending on the particular metal, its chemical bond, concentration, bioavailability and a host of other factors (including the age of the animal), the result can either be immunosuppression or immunoenhancement leading to hypersensitivity and autoimmunity (see Kakuschke & Prange, this issue). Studies on marine mammals from the North Sea have demonstrated a relationship between pollutant exposure and infectious disease mortality (Jepson et al., 2005). Higher levels of contaminants were also found in seals that died during the Phocine distemper virus epizootic that interrupted the increase of the harbor seal (*Phoca vitulina*) population in the Wadden Sea (Hall et al., 1992).

One population that may be particularly at risk from cumulative effects of noise and contaminants is the beluga whale population of the St Lawrence estuary. These beluga may already be quite compromised as they live in a historically highly polluted area (Fox, 2001; Lebeuf & Nunes, 2005; Lebeuf, Noëla, Trottier & Measures, 2007; Martineau, Béland, Desjardins & Lagacé, 1987; Muir et al., 1996; Muir, Koczanski, Rosenberg & Béland, 1996). For example, immunosuppressive contaminants most likely led to a high susceptibility to infections by opportunistic bacteria (i.e., bacteria that are part of the usual bacterial load in many animals and are not usually pathogenic) reported in the population (Martineau et al., 1988). High levels of shipping activity in the area is also exposing the whales to noise, with the imminent construction of a liquefied natural gas (LNG) terminal and planned natural gas exploration in the estuary set to raise noise levels further. As stressors related to contaminant loads are predominantly physiological and those related to noise are likely to be mostly psychological, increasing exposure to either also increases the risk of sickness-like conditions developing in the whales (e.g., neuroinflammation: Deak, this issue).

Tuna-dolphin fishery

The yellowfin tuna (*Thunnus albacares*) purse-seine fishery targets dolphins in the eastern tropical Pacific Ocean (ETP), as the tuna schools are associated with the dolphins. It should be noted that this makes it a somewhat unusual example of fisheries interactions, as marine mammals are not often targeted directly. However, there are a relatively large number of studies into the

effects of the ETP tuna fishery upon the dolphins, which is why it was selected as an example here.

Edwards (this issue) describes the process of chase, capture and release that the ETP dolphins are subjected to by the fishery. High mortality rates in the early days of the fishery (see Edwards, this issue) substantially reduced abundance in the two dolphin species most often involved (northeastern offshore spotted, *Stenella attenuata*, and eastern spinner, *S. longirostris*) to 20% - 30% of pre-fishery (1960) levels (Wade, Reilly & Gerrodette, 2002). Despite the substantial reduction of mortality rates to sustainable levels in 1990 due to the implementation of new fishing procedures, the populations do not appear to be recovering (Edwards, this issue; Gerrodette & Forcada, 2005).

Fishery-related stress responses (e.g., acute stress responses, "heat stress", etc.) became a suspected limiting factor in both of the most commonly targeted species, as the number of sets (i.e., the number of times dolphins are disturbed, chased and potentially captured) has not decreased (see Edwards, this issue). The role of capture myopathy (a disease complex involving muscle damage that is associated with the combination of intense physical exertion and physiological stress effects of capture or handling, and which can in some cases have immediate or delayed fatal consequences: Spraker, 1993) in the lack of recovery is yet to be fully determined for a number of reasons (see Reilly et al., 2005). However, it seems possible that detrimental sub-lethal consequences arising from each individual's stress response are playing an important role at the population level, at least through the more sensitive animals (see Edwards, this issue).

Great concern also surrounds the separation of calves from their mothers during fishery evasion, as the subsequent potential for unobserved calf mortality if not reunited promptly with their mother is quite high (Noren & Edwards, 2007). Even if calves are reunited, or do not suffer separation in the first place, there may still be serious consequences resulting from the experience. Neonates and young calves will be particularly sensitive to GCs because their brains are still developing, like all young mammals with immature nervous systems (see Romero & Butler, this issue). The purse-seine set experience, which appears to represent a severe but intermittent stressor to the ETP dolphins, may therefore have quite significant non-lethal effects on young calves. These would result from the double dose of GCs arising from the massive influx transmitted to them via the mother's milk as a consequence of her physiological stress response, combined with those produce by their own stress responses. These excessive stress-chemical loads have the potential for generating both acute neurological damage and long-lasting neurological re-programming in any nursing calves involved in evasion of a tuna purse-seine set in the ETP (see Sapolsky, 1992).

The various studies investigating fishery-related stress effects in ETP dolphins (e.g., changes in blood and muscle chemistry; damage to various organ systems, etc.: Reilly et al., 2005) illustrate the wide variety of impacts that can accompany an escape response (possibly acoustically-initiated) to an impending threat. At the present time, it is impossible to determine whether physiological effects of the whole chase/capture/escape experience are either short- or long-lived.

In general, physiological effects related to the stress response are likely to be reasonably short-lived for otherwise healthy adults in situations where even fairly intense natural stressors (e.g., predation attempts) occur only once every few weeks (see Dallman & Bhatnagar, 2001). Although the rate of occurrence may be similar in the ETP dolphins (see Edwards, this issue), surviving calves and fetuses in utero may still suffer a range of long-term impacts as they are exposed to maternal cortisol (if not also their own) each time their mother has been stressed during the chase-hunt, as discussed above. Some of these impacts may persist until the animals are adults and can include the development of an abnormal stress response system (e.g., Kapoor, Dunn, Kostaki, Andrews & Matthews, 2006). However, adults could also be affected as the chase process is characterized by an intensity and duration never encountered in nature (e.g., predators get tired and remain silent in contrast to motor vehicles). The set attempts likely involve both physiological and psychological stressors, such as noise and intense exercise, which may lead to sickness-like conditions in the exposed individuals (see Deak, this issue). Furthermore, the extent to which the stress response is involved in the initiation of capture myopathy has not yet been identified (see Reilly et al., 2005). The potential also exists for some serious cumulative impacts in dolphins of any age if they are in any way compromised prior to attempted purse-seine sets.

Acclimation in Marine Mammals

There is very little (if any) evidence of acclimation (as defined in Wright & Kuczaj, this issue) in marine mammals in the wild, although this does not mean that it does not occur. Many references to “habituation” have not demonstrated that the observed reduction in behavioral response is associated with a reduction in the physiological stress response and processes other than acclimation may explain the results (see Wright et al., this issue, a). For example, the observed reduction in behavioral responses of ETP dolphins when in the purse-seine net (i.e., originally they appeared to panic, but now seem to wait relatively passively until released), could indicate acclimation, but more likely indicates learning, and/or natural selection instead. It is important to recognize that these processes can change behavior in adaptive ways that nevertheless continue to be accompanied by a full internal physiological stress response.

Thus, apparent behavioral tolerance of noise in marine mammals cannot be automatically interpreted as acclimation (see Beale, this issue). However, there has been little opportunity for adaptation to noise to occur through natural selection in many marine mammals because of their long lifespans (except if there are lethal consequences of exposure to the stimulus: see below). This is especially true in large whales, as the increases in noise in the oceans may have occurred in a single lifetime. Consequently, an observed reduction in behavioral responses in marine mammals may often reflect a learning process, whereby repeated exposures to a stressor leads to reduced or altered behavioral responses, but not necessarily reduced physiological responses. The animals learn either how to behave to reduce any negative effects or that the stressor is not as noxious as it first appeared. However, the stimulus is still perceived as a stressor. It is then possible that this

information and any associated behaviors are conveyed to the next generation through cultural transmission.

With regards to the apparent acclimation in ETP dolphins to capture by the purse-seine the tuna-dolphin fishery, it is important to separately consider the capture by itself, as well as the whole purse-seine set experience collectively. It is unlikely that physiological acclimation to the whole purse-seine set activity occurs for several reasons. First, most ETP dolphins are only chased about once per month (and captured less often still; see Edwards, this issue) which is probably not often enough to lead to acclimation given the probable size of the stressor involved (although these catch frequency estimates are merely averages: some dolphins will evade sets more often, some will evade less often). Second, the dolphins still respond to capture efforts by fleeing immediately upon perception of an impending set (which, as an aside, is the cause of capture myopathy in free-ranging ruminants: Spraker, 1993). Third, they still engage in prolonged escape behavior after getting out of the net (also involved in capture myopathy: Spraker, 1993). Fourth, ETP dolphins in the more heavily fished areas exhibit escape reactions in response to all approaching big boats while responding less to vessels not approaching them directly (Au & Perryman, 1982; Hewitt, 1985), even though the combination of sounds that signal an approach are unlikely to be identical due to vessel and engine variety. Fifth, the number of ETP dolphins has been severely reduced. Finally, the social structure of the dolphins appears to have changed since the onset of the fishery as the average school size has decreased. Although the last two pieces of evidence do not necessarily reduce the likelihood that acclimation is at work, they suggest that other explanations for any tolerance displayed may be more likely, such as half a century of selective pressure (approximately four generations in these species: Myrick, Hohn, Barlow & Sloan, 1986).

It may be that the dolphins have acclimated somewhat to their temporary capture in the purse-seine nets, although the frequency of exposure remains a major issue (i.e., it may not occur frequently enough for acclimation to take place). Consequently, it appears more likely that the dolphins' relatively calm behavior reflects learning or selection, rather than acclimation. Furthermore, the dolphin's prolonged escape response after release from the net also implies that the animals have not acclimated to either capture or the full set experience. For example, it may be that, having experienced enough sets to realize that there is nothing they can do until the backdown maneuver (see Edwards, this issue), the dolphins may have learned to behave more calmly in the net, although they are very likely not internally calm at all. In comparison, learning to ignore the chase is unlikely as the result is uncertain: there is the possibility of either escape or capture.

As mentioned above, selective pressures may also be involved, fuelled by variation in individual susceptibilities to in-net mortality, the stressors of chase and capture, and possibly also capture myopathy. These factors, in combination with the fact that fishermen actively target larger schools, may have very quickly selected for dolphins that aggregated in smaller groups and behaved most appropriately to the sets. Consequently the reduction in apparent agitation in the net could be a result of the massive and efficient loss of the more sensitive individuals (potentially through unobserved capture myopathy in addition to direct

mortality in the net). Given the dramatic reduction in abundance, it appears reasonable that the remaining dolphins are those best 'suited' to surviving purse-seine sets.

Similar processes are also at work in modern fisheries. Observed effects include a reduction in the average size of collected fish, due to slower growth rates (within any given species), because only larger fish are big enough to be legally captured (see Conover & Munch, 2002). Under those conditions, fish that mature at a smaller size (either by growing slower or maturing earlier) have a selective advantage. However, smaller breeding animals may also have less resources and energy available to invest in reproduction, which could explain the associated reduction in egg size (Conover & Munch, 2002).

North Atlantic right whales

There are several possible explanations for the reactions of North Atlantic right whales to shipping noise and alarm sounds as discussed above (Nowacek et al., 2004). Two of the most likely are: 1) the whales have not learned to react to ship noise sounds appropriately (i.e., by swimming away), while they do not distinguish alarm sounds from those emitted by possible predators, such as killer whales; and 2) the whales have acclimated, wrongly, to continuous ship noise so that they do not react even at levels likely indicating danger of collision, while they do react to novel noise sources such as alarm sounds.

It is therefore no surprise that the following statements (which we demonstrate below are likely incorrect), with their associated management ramifications, are common in attempts to further understand why right whales do not appear to use sound to avoid ship strikes: 1) North Atlantic right whales appear to have "habituated" to ship noise, thus increasing the numbers and/or types of vessels in their coastal habitat does not constitute a potential threat to this endangered species; and/or 2) North Atlantic right whales have "habituated" to ship noise thus introduction of other industrial sounds to their coastal habitat does not constitute a potential threat to this endangered species.

If indeed right whales have actually acclimated to the constellation of low-frequency dominant sources in their environment, then the probability of a stress response occurring as a direct result of repeated exposure to industrial and vessel noise may be decreased. However, masking and signal discrimination would continue to create problems for right whale communication efficiency (and thus may indirectly lead to a stress response). In fact, the occurrence of ship strikes and entanglements in right whales may indicate that there is so much noise (or the noise has caused enough hearing damage) that the whales are unable to hear or locate anything except the loudest of sounds.

If acclimation is not occurring and a repeated and/or continuous stress response is being maintained by right whales due to a high incidence of exposure to acoustic and other stressors, then the observed lack of behavioral response in right whales may be due to various other factors. First, their physiological response to vessel noise exposure may not result in changes in behavior. Second, the animals may be less likely to respond if they are in poor overall health, perhaps as

chronically stressed individuals (see Beale & Monaghan, 2004). Third, any changes in behavior that do occur may be too subtle to have been detected, or have not been correctly identified (and thus recorded) by researchers due to a lack of understanding regarding the context for those changes. Finally and perhaps most likely, the whales just can't afford to react to ship noise as it happens all the time in the area they have to be in, so they carry on regardless (e.g., they have learned not to respond to the noise).

Given the lack of evidence for acclimation in this situation and in studies of other animals, as well as the discussion of acclimation above and in Wright et al. (this issue, a), it seems quite unlikely that North Atlantic right whales have acclimated, as defined, to loud sources of low frequency sound in their environments,. Consequently, the likelihood that the apparent tolerance is due to one or more of the other possible reasons needs to be considered in efforts to manage anthropogenic impacts on the species.

Conclusions

It is clear that noise can act as a stressor to marine mammals. If marine mammals react in a similar manner to other animals (including mammals) that have been studied in controlled circumstances, repeated and prolonged exposures to stressors (including or induced by noise) will be problematic for marine mammals of all ages. The resulting extended stress response may then lead to a range of issues including, but not limited to, suppression of reproduction (physiologically and behaviorally), accelerated aging, and sickness-like symptoms. Acclimation to such exposures seems unlikely for a number of reasons, including differences in the perceived stimuli, changing context, time-scales, etc. Examples of apparent "habituation" may instead indicate selection, or learning without acclimation. Learned responses, like acclimation, are highly dependent on the predictability of stimuli. However, learned responses, like other possible mechanisms of adaptation but unlike acclimation, may or may not reduce the magnitude of the physiological stress response.

Regardless, acclimation or some other apparent tolerance of a noise may have various pernicious effects, such as limiting the ability of the animals to react to actual threats. These may, in some cases, have lethal consequences (e.g. right whales' lack of reaction to ship noise, possibly resulting in collisions), but the majority of knock-on outcomes are likely to be physiological (e.g. dolphins approaching acoustic pingers, risking receiving noise levels with the potential to cause temporary hearing impairment, also known as a temporary threshold shift – TTS) or psychological (e.g., annoyance) effects that are not immediately lethal. However, physical injuries and other consequences of noise exposure may then act as additional stressors upon marine mammals. For example, if masking leads to increases in information ambiguity, or group or mother-calf separation, animals may suffer from anxiety as a result. Masking by increasing noise levels would be roughly analogous to a human trying to see through increasingly dirty glasses. Eventually, the lack of reliable acoustic information prevents marine mammals, especially cetaceans, from 'seeing' their environment, essentially leaving animals

blind. Confounding the issue further, maladaptive efforts to avoid a noise can also indirectly lead to detrimental outcomes for marine mammals.

In addition to the myriad possible affects from noise exposure that can all interact together, it is important to consider the potential cumulative effects of multiple anthropogenic stressors. For example, should the energy balance of a marine mammal become negative (due to disturbance or disease, etc.) lipids and the lipophilic contaminants stored within them are mobilized from the blubber. The release of these contaminants into the circulation not only constitutes *de facto* a second exposure to the individual concerned during a period of nutritional challenge, but mothers also expose newborns through transfer in milk (Martineau, Béland, Desjardins & Lagacé, 1987; Tornero et al., 2005; Wells et al., 2005). Affected animals would then be less able to respond sufficiently or appropriately to any additional stressors.

Further contextual complications may be involved in beaked whales and other deep diving marine mammal species, as their normal behavior may put them already at the limits of their physiological capabilities. Cumulative and synergistic effects can be assessed in different ways, but any such assessment should be undertaken very cautiously as synergistic effects can be very unpredictable. The following hypothetical chain of events illustrates the complexities of cumulative and synergistic effects in which noise-related stress may have deleterious consequences for a marine mammal.

A young male sperm whale in the Gulf of Mexico is exposed to nearby shipping noise and experiences a stress response. This response is more extreme than it would otherwise be as the young animal was exposed in utero and immediately after birth to high GC levels transferred through the placenta and milk from its mother, when she was undergoing a stress response. Despite a flight response sending the whale to the surface, the animal is lucky and avoids a potentially lethal ship strike. After repeated non-lethal exposures to that (or similar) sounds, the whale learns that the noise is not followed by any serious immediate consequences and so it stops responding behaviorally. Despite this, the animals GC levels remain high, because it has not acclimated to the passing ships and also because of its altered HPA axis. The resulting GC levels cause slow growth. If a ship passes nearby, the whale might experience TTS and/or the disruption of sleep, as well as interference in communication and foraging resulting from the masking. From time to time these problems annoy or agitate the whale and produce their own stress responses, depending on the exact situation.

As it ages, the sperm whale builds up a contaminant load over and above the dose it received as a calf from its mother. It also begins to suffer from bone damage related to diving. Frequent exposure to a variety of anthropogenic noise sources continues to disrupt foraging efforts and begins to directly affect its body condition and psychological outlook. A compromised immune system allows an infection to take hold and the whale begins to lose weight. Blubber is metabolized and the whale is exposed to the mobilization of its contaminant load. A seismic survey begins in the area and the resulting total exposure over the next several days exhausts the supply of components for GC production and pushes the combination of psychological and physiological stressors beyond a certain threshold, resulting

in neuroinflammation and other sickness-like conditions. In the face of this worsening condition, the sperm whale beaches itself and dies with no particular cause of death apparent.

Many of the effects discussed in this paper can be incorporated into population viability assessments and other models used by managers in their decision making process. There are a small number of studies in marine mammals where controls have been appropriately established that are beginning to provide some of the information required for this. However, for the majority of marine mammals, accounting for these effects will require some assumptions about the implications of the various stress responses on fecundity and survivorship, as the data that concern these parameters are not available. Fortunately, extrapolation from data in other species (and possibly even from other animal groups) appears reasonable, because the physiological stress response is highly conserved across the many different species that have been studied to date.

In addition to the more general conclusions and findings offered by Wright et al. (this issue, a) pertaining to stress responses to noise, we suggest that the following findings and recommendations (presented in no particular order) are especially important with regards to marine mammals. We propose that marine mammal managers and scientists consider these findings and specific recommendations when planning research or management actions (e.g., in assessments of environmental impact).

Findings

1. "Stress" is a very important concept to consider in managing the impacts of anthropogenic activities on marine mammals, yet definitions vary greatly among specialists as well as laymen. There is also much confusion over the use of the related term "habituation" (see also Wright et al., this issue, a).

2. Given the physiological, psychological, behavioral and ecological information presented, considered and discussed in this issue, the conclusions that have been drawn from them, and the other findings presented here, it is reasonable to assume that anthropogenic noise, either by itself and/or in combination with other stressors, can reduce the fitness of individual marine mammals and decrease the viability of some marine mammals populations.

3. The physiological stress response is highly conserved among those animal species in which it has been studied (including a few marine mammal species: e.g., Martineau, this issue) and thus extrapolation to marine mammals is reasonable.

4. Very young individuals (and fetuses) are particularly sensitive to the neurological consequences of the stress response and can suffer permanent neurological alterations as a result. Similarly, deep diving marine mammals may be particularly sensitive to noise as a stressor given that many marine mammal species are thought to live close to their physiological limits.

5. Acoustic masking may act in several ways to induce stress responses in marine mammals. These may include but are not limited to: reducing the range of signals important for communication and finding of prey; reducing the clarity of received signals; and inducing anxiety and annoyance. These combine with potential effects on foraging efficiency and social cohesion, with possible subsequent effects on reproductive success and survivorship.

6. Scientists need to study stress responses in marine mammals and their epidemiological and psychological consequences. Most immediately, classical stress measures will be needed to marry the extrapolations from studies in other animals with observed behavioral responses. Such studies will be complex and require defining concepts such as "need" and "risk" in terms of the decision making process in the often highly developed brains of marine mammals. Adequate techniques to obtain physiological data (e.g., heart rates, cortisol levels, adrenal morphology and other information) are also required. Implicitly, these various techniques should be the least invasive as possible to minimize additional stressors. It is also very important to include a comparison or control group (i.e., mammals not exposed) or baseline data (i.e., data from animals before they became exposed). However it is acknowledged that non-exposed populations of marine mammals are likely to be quite rare.

Research Recommendations

1. Efforts should be made to collect information on the dynamics of stress-related chemicals (particularly cortisol) in cetaceans and other marine mammals. Collection from blood plasma may not currently be practical for assessing the effects of most stressors, given that animals would generally need to be captured, which is a complex task when handling large marine mammals. Currently available methodologies that do not require capture involve the collection of feces from free-ranging animals (either after visual detection or through the use of the canine sense of smell: Hunt, Rolland, Kraus & Wasser, 2006), or the collection of mucus expelled during exhalation (Hogg, Vickers, & Rogers, 2005). The time between exposure to a stressor and the increase in cortisol levels in the various samples need to be considered. The period from stressor exposure to increased cortisol levels is very short in blood samples. In contrast, cortisol levels in samples from feces will be averaged between bowel movements, and those from samples of respiratory mucus exhaled with a breath are likely to take 10-15 minutes or more to reflect the impact of a stressor. Cortisol levels in fecal and mucosal samples are likely to be more variable than in blood samples, but the less invasive collection methods are less likely to trigger a stress response of their own, allowing the techniques to be used to study the effects of other stressors, such as noise. Such investigations would need to be carefully constructed, with well-designed controls. Efforts should acknowledge that is not possible to distinguish between acute and chronic stress responses in blood, fecal and mucosal

samples without a time-series. It should also be noted that animals often expel fecal matter as part of a sympathetic response when they become stressed. In addition, GC levels are fairly variable from one individual to another, so baselines will be needed for each individual against which to measure relative stress levels.

2. Opportunistic collection of information about the level of stress-related chemicals from various tissues and stores in stranded and bycaught animals should also be undertaken. Investigations should also be made to see if it is possible to obtain these chemicals from skin and/or blubber. If so, the amounts in the blubber may be long-term average levels, providing indication of cumulative stress responses for marine mammals over the long-term. However, there is some active exchange between the blubber and the blood, so levels of stress-related chemicals in the different layers of the blubber may reflect shorter-term averages, although there may also be high variability both between and within species. Post mortem examinations of stranded marine mammals should also record other pathologic effects related to exposure to stressors. For example, the size and weight of, as well as the presence of any lesions on, the adrenal glands should be noted. Chronic stress leads to chronic stimulation of the adrenal cortex by adrenocorticotrophic hormone (ACTH). In turn, ACTH chronic stimulation results in adrenocortical hyperplasia (increased number of cells) or hypertrophy (increased size of cells) necessary to allow for sustained overproduction of GC and possibly catecholamines. These morphological changes are seen grossly as increased size and weight of the adrenal glands (Clark, Cowan & Pfeiffer, 2006; Dorovini-Zis & Zis, 1987; Lair, Beland, De Guise & Martineau, 1997; Nemeroff et al., 1992; Ulrich-Lai, Figueiredo, Ostrander, Choi, Engeland & Herman, 2006). Furthermore, the presence of acute phase proteins in different organs, such as the liver or skin, could indicate recent exposure to an intense stressor. This could also provide important information on “normal” background levels of the proteins in different species, which would be very useful in developing further studies on the evaluation of stress response in marine mammals.

3. Skin biopsies, sampled from live cetaceans with minimal disturbance, have yielded unique information about genetics and contaminants (Fossi et al., 2004; Hobbs et al., 1998). Not only is skin a major target organ for cortisol (and thus cortisol is present in the skin) but skin is also a site of cortisol synthesis (Slominski, Wortsman, Tuckey & Pau, 2007). Measurement of cortisol levels in skin biopsies carried out on free-ranging cetaceans should be explored, although the possible effects of any chase and handling required to obtain the samples needs to be considered. It may also be possible to obtain this information through collection of sloughed skin from the water in the wake of a whale, which could largely circumvent this problem.

4. Given that studies on cortisol in humans have generated mixed results, efforts should also be made to study epidemiological effects in marine mammals, especially in the wild.

A Strategy for Managing the Impacts of Noise on Cetaceans in the Face of Uncertainty

Based on the available evidence, a non-trivial negative impact of noise-related stress responses on vital rates is expected for many marine mammals, especially cetacean species, although there is still substantial research needed to determine the magnitude of impacts. The Bayesian approach outlined by Wintle (this issue) is likely to be viable, logical and coherent in quantifiably extrapolating noise-related impacts from other mammals to cetaceans, given the highly conserved nature of stress physiology.

There are clearly grounds to justify initiating an adaptive noise mitigation strategy based on the available evidence and theory concerning the impacts of both acute and chronic noise on humans and terrestrial mammals, as well as the sparse data available on cetacean noise impacts. Potential noise exclusion zones should be identified as a matter of urgency. However, in order to commence the learning cycle, it is essential to measure vital rates under both noisy and noise-excluded management conditions so that the specific benefits of noise exclusion/mitigation can be better understood. Until an adequately stratified study of cetacean vital rates under various levels of noise impacts can be established, the value of noise mitigation efforts will be clouded by uncertainty. It is acknowledged that this will be a difficult and lengthy task.

A detailed description of a suitable management and monitoring strategy to assess the impacts of noise and noise mitigation on cetacean vital rates is beyond the scope of this issue. However, some general recommendations to those managing the impacts of noise on marine mammals can be made. We recommend that:

1. An expert working group should be convened with the specific goal of identifying noise impacts on cetacean (or other marine mammal) vital rates, using all available data and systematically integrating knowledge of impacts from other species.

2. Areas suitable for broad-scale noise exclusion/reduction should be identified.

3. Where possible, environmentally similar areas that cannot have noise exclusions/reductions should also be identified.

4. Based on the results of expert working groups, models should be developed to predict likely population responses to noise mitigation strategies.

5. Levels of noise should be closely monitored and measurement of cetacean vital rates initiated in all locations.

6. The relationship between noise level and cetacean vital rates may then be updated and predictions about future gains modified to reflect the new information.

7. Monitoring of vital rates should be maintained to enable better decisions about future allocation of mitigation efforts.

References

Aguilar Soto, N., Johnson, N., Madsen, P. T., Tyack, P. L., Bocconcelli, A. & Borsani, J. F. (2006). Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? *Marine Mammal Science*, **22**(3), 690–699.

Allison, P. A., Smith, C. R., Kukert, H., Deming, J. W. & Bennett, B. A. (1991). Deep-water taphonomy of vertebrate carcasses: A whale skeleton in the Bathyal Santa Catalina Basin. *Paleobiology*, **17**(1), 78-89.

Arveson, P. T. & Venditis, D. J. (2000). Radiated noise characteristics of a modern cargo ship. *Journal of the Acoustical Society of America*, **107**, 118–129.

Au, D. & Perryman, W. (1982). Movement and speed of dolphin schools responding to an approaching ship. *Fishery Bulletin*, **80**(2), 371-379.

Au, W. W. L. (1993). *The Sonar of Dolphins*. New York, NY: Springer-Verlag.

Baldwin, A. L. (this issue). Effects of noise on rodent physiology. *International Journal of Comparative Psychology*, **this issue**, 134-144.

Bateson, M. (this issue). Environmental noise and decision making: possible implications of increases in anthropogenic noise for information processing in marine mammals. *International Journal of Comparative Psychology*, **this issue**, 169-178.

Beale, C. M. & Monaghan, P. (2004). Behavioural responses to human disturbance: a matter of choice? *Animal Behaviour*, **68**, 1065-1069.

Beale, C. M. (this issue). The behavioral ecology of disturbance responses. *International Journal of Comparative Psychology*, **this issue**, 111-120.

Beckmen, K. B., Blake, J. E., Ylitalo, G. M., Stott, J. L. & O'Hara, T.M. (2003). Organochlorine contaminant exposure and associations with hematological and humoral immune functional assays with dam age as a factor in free-ranging northern fur seal pups (*Callorhinus ursinus*). *Marine Pollution Bulletin*, **46**(5), 594-606.

Bejder, L., Samuels, A., Whitehead, H., Gales, N., Mann, J., Connor, R. C., Heithaus, M. R., Watson-Capps, J., Flaherty, C. & Krutzen, M. (2006). Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology*, **20**(6), 1791-1798.

Carretta, J. V., Forney, K. A., Muto, M. M., Barlow, J., Baker, J., Hanson, B. & Lowry, M. S. (2007). U.S. Pacific Marine Mammal Stock Assessments: 2006. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Technical Memorandum NOAA-TM-NMFS-SWFSC-398. La Jolla, CA: Southwest Fisheries Science Center. Available at: http://www.nmfs.noaa.gov/pr/pdfs/sars/po2006.pdf.

Clark, C. & Stansfeld, S. A. (this issue). The effect of transportation noise on health & cognitive development: A review of recent evidence. *International Journal of Comparative Psychology*, **this issue**, 145-158.

Clark, L. S., Cowan, D. F., & Pfeiffer, D. C. (2006). Morphological Changes in the Atlantic Bottlenose Dolphin (*Tursiops truncatus*) Adrenal Gland Associated with Chronic Stress. *Journal of Comparative Pathology*, **135**(4), 208-216.

Conover, D. O. & Munch, S. B. (2002). Sustaining fisheries yields over evolutionary time scales. *Science*, **297**, 94-96.

Cox, T. M., Ragen, T. J., Read, A. J., Vos, E., Baird, R. W., Balcomb, K., et al. (2006). Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management*, **7**(3), 177-187.

Crum, L. A. & Mao, Y. (1996). Acoustically enhanced bubble growth at low frequencies and its implications for human diver and marine mammal safety. *Journal of the Acoustical Society of America*, **99**(5), 2898-2907.

Dallman, M. F. & Bhatnagar, S. (2001). Chronic stress and energy balance: Role of the hypothalamo-pituitary-adrenal axis. In B. S. McEwen and H. M. Goodman (Eds.), *Handbook of Physiology; Section 7: The Endocrine System; Volume IV: Coping with the Environment: Neural and Endocrine Mechanisms* (pp. 179-210). New York: Oxford University Press.

Deak, T. (this issue). From classic aspects of the stress response to neuroinflammation and sickness: Implications for individuals and offspring of diverse species. *International Journal of Comparative Psychology*, **this issue**, 96-110.

Dorovini-Zis, K. & Zis, A. P. (1987). Increased adrenal weight in victims of violent suicide. *American Journal of Psychiatry*, **144**, 1214-1215.

Edwards, E. F. (this issue). Fishery effects on dolphins targeted by tuna purse-seiners in the Eastern Tropical Pacific Ocean. *International Journal of Comparative Psychology*, **this issue**, 217-227.

Fernández, A., Edwards, J. F., Rodríguez, F., Espinosa de los Monteros, A., Herráez, P., Castro, P., Jaber, J. R., Martín, V. & Arbelo, M. (2005). "Gas and fat embolic syndrome" involving a mass stranding of beaked whales (family *Ziphiidae*) exposed to anthropogenic sonar signals. *Veterinary Pathology*, **42**, 446-457.

Fossi, M. C., Marsili, L., Lauriano, G., Fortuna, C., Canese S., Ancora, S., Leonzio, C., Romeo, T., Merino, 5., Abad, E. & Jiménez, B. (2004). Assessment of toxicological status of a SW Mediterranean segment population of striped dolphin (*Stenella coeruleoalba*) using skin biopsy. *Marine Environmental Research*, **58**, 269-274.

Fox, G.A. (2001). Wildlife as sentinels of human health effects in the Great Lakes–St. Lawrence Basin. *Environmental Health Perspectives*, **109**(suppl 6), 853–861.

Gerrodette, T. & Forcada, J. (2005). Non-recovery of two spotted and spinner dolphin populations in the eastern tropical Pacific Ocean. *Marine Ecology Progress Series*, **291**, 1-21.

Godinho, A., Jaber, J., Castro, P., Méndez, M., Jepson, P., & Fernández, A. (2007). Ultrastructural findings of intracytoplasmic eosinophilic globules in hepatocytes of stranded cetaceans. *Poster Presentation at the 21st Annual Meeting of the European Cetacean Society*. San Sabastian, Spain.

Godinho, A., Jepson, P., Deville, R., Castro, P., Jaber, J. & Fernández, A. (2006). Intracytoplasmic eosinophilic globules in hepatocytes of by-caught harbour porpoises (*Phocoena phocoena*). *Poster Presentation at the 20th Annual Meeting of the European Cetacean Society*. Gdynia, Poland.

Godinho, A., Monti, G., Arbelo, M., Silvosa, M., Sierra, E., Castro, P., Jaber, J., Rodríguez, F. & Fernández, A. (2005). Intracytoplasmic eosinophilic globules in hepatocytes of stranded cetaceans in the Canary Islands. *Poster Presentation at the 19th Annual Meeting of the European Cetacean Society*. La Rochele, France.

Hall, A. J., Law, R. J., Wells, D. E., Harwood, J., Ross, H. M., Kennedy, S., Allchin, C. R., Campbell, L. A. & Pomeroy, P. P. (1992). Organochlorine levels in common seals (*Phoca vitulina*) which were victims and survivors of the 1988 phocine distemper epizootic. *Science of the Total Environment*, **115**, 145-162.

Hatch, L. & Wright, A. J. (this issue). A brief review of anthropogenic sound in the oceans. *International Journal of Comparative Psychology*, **this issue**, 121-133.

Hewitt, R. P. (1985). Reaction of dolphins to a survey vessel: Effects on census data. *Fishery Bulletin*, **83**(2), 187-193.

Hildebrand, J. A. (2005). Impacts of anthropogenic sound. In J. E. Reynolds III, W. F. Perrin, R. R. Reeves, S. Montgomery & T. J. Ragen (Eds.), *Marine Mammal Research: Conservation Beyond Crisis* (pp. 101-124). Baltimore: Johns Hopkins University Press

Hobbs, K. E., Muir, D. C., Michaud, R., Béland, P., Letcher, R. J. & Norstrom, R. J. (1998). PCBs and organochlorine pesticides in blubber biopsies from free-ranging St. Lawrence River Estuary beluga whales (*D. leucas*), 1994-1998. *Environmental pollution*, **122**(2), 291-302.

Hogg, C. J., Vickers, E. R. & Rogers, T. L. (2005). Determination of testosterone in saliva and blow of bottlenose dolphins (*Tursiops truncatus*) using liquid chromatography-mass spectrometry. *Journal of Chromatography B*, **814**, 339-346.

Houser, D. S., Howard, R. & Ridgway, S. (2001). Can Diving-induced Tissue Nitrogen Supersaturation Increase the Chance of Acoustically Driven Bubble Growth in Marine Mammals? *Journal of Theoretical Biology*, **213**, 183-195.

Hunt, K. E., Rolland, R. A., Kraus, S. D. & Wasser, S. K. (2006). Analysis of fecal glucocorticoids in the North Atlantic right whale (*Eubalaena glacialis*). *General and Comparative Endocrinology*, **148**, 260-272.

Jepson, P. D., Bennett, P. M., Deaville, R., Allchin, C. R., Baker, J. R. & Law, R. J. (2005). Relationships between polychlorinated biphenyls and health status in harbor porpoises (*Phocoena phocoena*) stranded in the United Kingdom. *Environmental Toxicology and Chemistry*, **24**, 238-248.

Jepson, P. D., Arbelo, M., Deaville, R., Patterson, I. A. P., Castro, P., Baker, J. R., et al. (2003). Gas-bubble lesions in stranded cetaceans. *Nature*, **245**, 575-576.

Johnson, M. & Tyack, P. L. (2003). A digital acoustic recording tag for measuring the response of wild marine mammals to sound. *IEEE Journal of Oceanic Engineering*, **28**, 3-12.

Kakuschke, A. & Prange, A. (this issue). The influence of metal pollution on the immune system - a potential stressor for marine mammals in the North Sea. *International Journal of Comparative Psychology*, **this issue**, 179-193.

Kapoor, A., Dunn, E., Kostaki, A., Andrews, M. H. & Matthews, S. G. (2006). Fetal programming of hypothalamo-pituitary-adrenal function: Prenatal stress and glucocorticoids. *The Journal of Physiology*, **572**(1), 31–44.

Lair, S., Beland, P., De Guise, S. & Martineau, D. (1997). Adrenal hyperplastic and degenerative changes in beluga whales. *Journal of Wildlife Diseases*, **33**(3), 430-437.

Lebeuf, M. & Nunes, T. (2005). PCBs and OCPs in sediment cores from the lower St. Lawrence Estuary, Canada: Evidence of fluvial inputs and time lag in delivery to coring sites. *Environmental Science & Technology*, **39**(6), 1470-1478.

Lebeuf, M., Noëla, M., Trottier, S. & Measures, L. (2007). Temporal trends (1987–2002) of persistent, bioaccumulative and toxic (PBT) chemicals in beluga whales (*Delphinapterus leuca*s) from the St. Lawrence Estuary, Canada. *Science of the Total Environment*, **383**(1-3), 216-231.

Lusseau D. & Bejder, L. (this issue). The long-term consequences of short-term responses to disturbance: Experiences from whalewatching impact assessment. *International Journal of Comparative Psychology*, **this issue**, 228-236.

Lusseau, D. (2003). Male and female bottlenose dolphins (*Tursiops* spp.) have different strategies to avoid interactions with tour boats in Doubtful Sound, New Zealand. *Marine Ecology Progress Series*, **257**, 267-274.

Lusseau, D., Slooten, E. & Currey, R. J. (2006). Unsustainable dolphin watching activities in Fiordland, New Zealand. *Tourism in Marine Environments*, **3**(2), 173-178.

Martineau, D. (this issue). Potential synergism between stress and contaminants in free-ranging cetaceans. *International Journal of Comparative Psychology*, **this issue**, 194-216.

Martineau, D., Béland, P., Desjardins, C. & Lagacé, A. (1987). Levels of organochlorine chemicals in tissues of beluga whales (*Delphinapterus leucas*) from the St. Lawrence Estuary, Québec, Canada. *Archives of Environmental Contamination and Toxicology*, **16**(2), 137-147.

Martineau, D., Lagacé, A., Béland, P., Higgins, R., Armstrong, D. & Shugart, L. R. (1988). Pathology of stranded beluga whales (*Delphinapterus leucas*) from the St. Lawrence Estuary, Québec, Canada. *Journal of Comparative Pathology*, **98**(3), 287-311.

Miksis-Olds, J. L., Donaghay, P. L., Miller, J. H., Tyack, P. L. & Reynolds, J. E. (2007). Simulated vessel approaches elicit differential responses from manatees. *Marine Mammal Science*, **23**(3), 629-649.

MMC – U.S. Marine Mammal Commission (2007). Marine Mammal Commission Annual Report to Congress 2006. Bethesda, MD: U.S. Marine Mammal Commission. This and previous reports are available online at: http://www.mmc.gov/reports/annual/.

Moore, M. J. & Early, G. A. (2004). Cumulative sperm whale bone damage and the bends. *Science*, **306**(5705), 2215.

Muir, D. C., Koczanski, K., Rosenberg, B., & Béland, P. (1996a). Persistent organochlorines in beluga whales (*Delphinapterus leucas*) from the St Lawrence River estuary--II. Temporal trends, 1982-1994. *Environmental Pollution*, **93**(2), 235-245.

Muir, D. C. G., Ford, C. A, Rosenberg, B., Norstrom, R. J., Simon, M., & Briand, P. (1996b). Persistent organochlorines in beluga whales (*Delphinapterus leucas*) from the St Lawrence Estuary -I. Concentrations and patterns of specific PCBS, chlorinated pesticides and polychlorinated dibenzo-p-dioxins and dibenzofurans. *Environmental Pollution*, **93**(2), 219-234.

Myrick, A.C., Hohn, A.A., Barlow, J. & Sloan, P.A. (1986). Reproductive biology of female spotted dolphins, *Stenella attenuata*, from the eastern tropical Pacific. *Fishery Bulletin*, **84**(2), 247-259.

Nemeroff, C. B., Krishnan, K. R., Reed, D., Leder, R., Beam, C. & Dunnick, N. R. (1992). Adrenal gland enlargement in major depression. A computed tomographic study. *Archives of General Psychiatry*, **49**(5), 384-387.

Noren, S. R. & Edwards, E. F. (2007). Physiological and behavioral development in delphinid calves: Implications for calf separation and mortality due to tuna purse-seine sets. *Marine Mammal Science*, **23**(1), 15-29.

Nowacek, D., Johnson, M. & Tyack, P. L. (2004). North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alarm stimuli. *Proceedings of the Royal Society of London B*, **271**, 227–231.

NRC – U.S. National Research Council (1994). *Low-Frequency Sound and Marine Mammals: Current Knowledge and Research Needs*. Washington, DC: National Academy Press. 75 pp.

NRC – U.S. National Research Council (2003). *Ocean Noise and Marine Mammals*. Washington, DC: National Academy Press. 192 pp.

Payne, R. & Webb, D. (1971). Orientation by means of long range acoustic signaling in baleen whales in: Orientation: Sensory basis. *Annals of the New York Academy of Sciences*, **188**, 110-142.

Popper, A. N. (2003). The effects of anthropogenic sounds on fishes. *Fisheries*, **28**(10), 24-31.

Rabin, L. A., & Greene, C. M. (2002). Changes in acoustic communication systems in human-altered environments. *Journal of Comparative Psychology*, **116**(2), 137-141.

Reeves, R. R. & Ragen, T. J. (2004) *Future Directions in Marine Mammal Research: Report of the Marine Mammal Commission Consultation August 4-7, 2003*. Bethesda, MD: Marine Mammal Commission. 79pp. Available at: http://www.mmc.gov/reports/workshop/pdf/Futuredirectionsreport.pdf.

Reilly, S. B., Donahue, M. A., Gerrodette, T., Forney, K., Wade, P., Ballance, L., et al. (2005). *Report of the Scientific Research Program Under the International Dolphin Conservation Program Act*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service Technical Memorandum NOAA-TM-NMFS-SWFSC-372. La Jolla, CA: Southwest Fisheries Science Center. 100 pp. Available at: http://swfsc.noaa.gov/publications/tm/swfsc/noaa-tm-nmfs-swfsc-372.pdf.

Richardson, W. J., Greene, C. R., Malme, C. I., & Thomson, D. H. (1995). *Marine Mammals and Noise*. San Diego, CA: Academic Press, Inc. 576pp.

Romano, T. A., Keogh, M. J., Kelly, C., Feng, P., Berk, L., Schlundt, C. E., Carder, D. A. & Finneran, J. J. (2004). Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. *Canadian Journal of Fisheries and Aquatic Sciences*, **61**, 1124-1134.

Romero, L. M. & Butler, L. K. (this issue). Endocrinology of stress. *International Journal of Comparative Psychology*, **this issue**, 89-95.

Rommel, S. A., Costidis, A. M., Fernández, A., Jepson, P. D., Pabst, D. A., Mclellan, W. A., et al. (2006). Elements of beaked whale anatomy and diving physiology and some hypothetical causes of sonar-related stranding. *Journal of Cetacean Research and Management*, **7**(3), 189-209.

Sapolsky, R.M. (1992). *Stress, the Aging Brain, and the Mechanisms of Neuron Death*. Cambridge, MA: MIT Press.

Selye, H. (1946). The general adaptation syndrome and the diseases of adaptation. *Journal of Clinical Endocrinology*, **6**, 117-230.

Slominski, A., Wortsman, J., Tuckey, R. C. & Pau, R. (2007). Differential expression of HPA axis homolog in the skin. *Molecular and Cellular Endocrinology*, **266**, 143-149.

Southall, B. L. (2005). *Final Report of the International Symposium, 'Shipping Noise and Marine Mammals: A Forum for Science, Management, and Technology.' 18-19 May 2004 Arlington, Virginia, U.S.A.* National Oceanic and Atmospheric Administration, National Marine Fisheries Service Technical report. Silver Spring, MD: NOAA Fisheries Acoustics Program. Available at: http://www.nmfs.noaa.gov/pr/pdfs/acoustics/shipping_noise.pdf.

Spraker, T. R. (1993). Stress and capture myopathy in artiodactyls. In Fowler, M.E. (Ed.), *Zoo and Wild Animal Medicine. 3rd edition* (p. 481-488). Philadelphia PA: W.B. Saunders.

Thomas, J. A., Kastelein, R. A. & Awbrey, F. T. (1990). Behavior and blood catecholamines of captive belugas during playbacks of noise from an oil drilling platform. *Zoo Biology*, **9**, 393-402.

Tornero, V., Borrell, A., Aguilar, A., Wells, R. S., Forcada, J., Rowles, T. K. & Reijnders, P. J. H. (2005). Effect of organochlorine contaminants and individual biological traits on blubber retinoid concentrations in bottlenose dolphins (*Tursiops truncatus*). *Journal of Environmental Monitoring*, **7**, 109–114.

Tyack, P. L., Johnson, M., Aguilar Soto, N., Sturlese, A. & Madsen, P. T. (2006). Extreme diving of beaked whales. *Journal of Experimental Biology*, **209**, 4238-4253.

Tyack, P. L. & Miller, E. H. (2002). Vocal anatomy, acoustic communication and echolocation. In A.R. Hoelzel (Ed.), *Marine Mammal Biology* (pp. 142-184). Oxford, UK: Blackwell Science Ltd.

Ulrich-Lai, Y. M., Figueiredo, H. F., Ostrander, M. M., Choi, D. C., Engeland, W. C. & Herman, J. P. (2006). Chronic stress induces adrenal hyperplasia and hypertrophy in a subregion-specific manner. *American Journal of Physiology – Endocrinology and Metabolism*, **291**(5), E965-E973. (doi:10.1152/ajpendo.00070.2006).

Urick, R.J. (1983). *Principles of Underwater Sound, 3rd edition*. New York: McGraw-Hill, New York. 423pp.

Wade, P. R., Reilly, S. B. & Gerrodette, T. (2002). *Assessment of the Population Dynamics of the Northeast Offshore Spotted and the Eastern Spinner Dolphin Populations Through 2002*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service Administrative Report LJ-02-13. La Jolla, CA: Southwest Fisheries Science Center. 58pp. Available at: http://swfsc.noaa.gov/uploadedFiles/Divisions/PRD/Programs/ETP_Cetacean_Assessment/LJ_02_13.pdf.

Weilgart, L. S. (this issue). A brief review of known effects of noise on marine mammals. *International Journal of Comparative Psychology*, **this issue**, 159-168.

Wells, R. S., Tornero, V., Borrell, A., Aguilar, A. A., Rowles, T. K., Rhinehart, H.L., et al. (2005). Integrating life-history and reproductive success potential relationships with organochlorine compounds bottlenose dolphins (*Tursiops truncatus*) in Sarasota. *Science of the Total Environment*, **349**, 106–119.

Williams, R., Lusseau, D. & Hammond, P.S. (2006). Potential energetic cost to killer whales of disturbance by vessels and the role of a marine protected area. *Biological Conservation*, **133**(3), 301-311.

Wintle, B. A. (this issue). Adaptive management, population modelling and uncertainty analysis for assessing the impacts of noise on cetacean populations. *International Journal of Comparative Psychology*, **this issue**, 237-250.

Wobeser, G. (1994). *Investigation and Management of Disease in Wild Animals*. New York: Plenum Press. 256 pp.

Wright, A. J. & Kuczaj, S. (this issue). Noise-related stress and marine mammals: An introduction. International Journal of Comparative Psychology, **this issue**, iii-viii.

Wright, A. J., Aguilar Soto, N., Baldwin, A. L., Bateson, M., Beale, C., Clark, C., et al. (this issue). Anthropogenic noise as a stressor in animals: a multidisciplinary perspective. *International Journal of Comparative Psychology*, **this issue**, 250-273.

Appendix 1

The following table compares some of the scientific evidence for physiological, psychological and behavioral responses to various stressors with some of the known behavioral effects of noise in marine mammals and other species. It should not be considered an exhaustive list. It should also be noted that authors contributed predominantly to the rows in which they had expertise. This has given rise to different application of the columns "mechanisms', 'observations' and 'consequences'. For example, in some cases a physiological stress response is listed as a consequence, while in others the whole response is, or elements of it are, listed as either a mechanism and/or an observation. These inconsistencies highlight the diverse approaches in the various disciplines and may arise from the different methodologies available to the scientists in the various fields and from one species to another. They should therefore not necessarily be interpreted as inconsistencies in the actual results. Finally, some of the potential impacts resulting from noise exposure discussed in this and other papers in this issue have been added to many of the marine mammal entries as possible consequences. Items in italics are uncertain and those marked '*???*' are unknown.

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
General	Chronic/cumulating acute non-specific (e.g., contaminants, predators, etc.)	Chronic GC response.	Increased GC levels prior to eventual fall-off.	Chronic: Disregulation of glucose and metabolism; Stress-induced dwarfism; Behavioral changes (context dependant); Reproductive disruption (psychological and physiological); Immune-suppression.	McEwen & Goodman, 2001; Sapolsky, Romero & Munck, 2000
Guinea pigs	Maternal separation	*Probable increase cytokine expression?*	See consequences.	Initial anxiety followed by 'sickness'.	Hennessy et al., 2007
Lab rat	Footshock	Increase cytokine expression and microglial activation and CNS.	See consequences.	'Sickness' behavior, Neurodegeneration.	Deak, Bellamy & D'Agostino, 2003; Nguyen et al., 1998; Plata-Salaman et al., 2000; Shintani et al., 1995
Lab rat	White noise (experimental)	Release of corticosterone; Intestinal inflammation; Microvasular damage; Transient increase in blood pressure.	Redness around eyes and on back of neck. Also see mechanisms.	Non-selective molecular exchange intestine-blood stream leading to septicemia.	Baldwin, Primeau & Johnson, 2006; Baldwin & Bell, 2007; Burwell & Baldwin, 2006; Windle et al., 1998

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
Humans	Aircraft noise, road traffic noise, community/ambient noise and occupational noise	Physiological responses: Hypertension; Coronary heart disease (CHD).	Increased systolic BP or hypertension diagnosis; Increased rates of CHD.	Problems with hypertension leading to heart disease; CHD; Annoyance.	Babisch, 2006; van Kempen et al., 2002; Babisch, 2000
Humans	Aircraft noise, road traffic noise, community/ambient noise and occupational noise	Physiological responses in adults and children: Stress hormones in the endocrine system (cortisol, adrenaline, noradrenaline).	Increased levels of these hormones being measured in urine and saliva.	Evidence linking stress hormone levels to health impairment is lacking but raised levels may impact of peripheral vascular system; Annoyance.	Babisch, 2003 (meta-analysis)
Humans	Aircraft noise, road traffic noise, community/ambient noise and occupational noise	Sleep disturbance.	Increased awakenings due to noise exposure; Taking longer to fall asleep; Evidence that habituation (as defined by Clark & Stansfeld, this issue) to exposure occurs.	Performance effects; Mood effects; Health effects associated with sleep disturbance; Noise during sleep may also stimulate heart rate; Annoyance.	Basner & Samel, 2005; HCN 2004; Miedema & Vos, 2007
Humans	Aircraft noise, road traffic noise, community/ambient noise	Psychological health.	Dose-response relationships between aircraft noise and depressiveness in adults; Some child studies have found increase reports of poor psychological health but others haven't.	Poor psychological functioning, wellbeing, quality of life.	Haines et al., 2001; Haines et al., 2001; Hiramatsu et al., 2000; Lercher et al., 2002; Stansfeld et al., 2005
Humans	Aircraft noise, road traffic noise, community/ambient noise	Children's cognition.	Impaired reading and short-term and long-term memory.	Impact on children’s learning and schooling.	Clark et al., 2006; Haines et al., 2001; Haines et al., 2001; Hygge, Evans & Bullinger, 2002; Stansfeld et al., 2005
Wedge-tailed eagle	Forestry operations *(chainsaw noise??)*	Fleeing.	Nest abandonment.	Breeding failure (for that year).	Mooney & Holdsworth, 1991; Mooney & Taylor, 1996

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
Robin	Ambient Noise	*Masking?*	Nocturnal Singing.	Increased risk of predation; Sleep deprivation.	Fuller, Warren & Gaston, 2007
Starlings	Barren cages	Anxiety.	Risk averse foraging.	Reduced intake of food.	Bateson & Matheson, 2007; Matheson, Asher & Bateson, 2007
Turnstones	Human presence	'Decision' based on context.	Variable alert and evasive depending on context.	Probably minimal (in this case).	Beale & Monaghan, 2004a
Kittiwake	Human presence	*Sympathetic responses?*	Variable: Elevated heart rate; Sleep/Awake proportion.	Variable: Increase nest failure (debatable long-term impact).	Beale & Monaghan, 2004a, 2004b
Wood lark	Human presence	'Decision' based on context.	Variable: nest selection; Disturbance avoidance.	Complicated: Potentially population level effects.	Mallord et al., 2007
Seals	Pollutants	Immunmodulation by metal (pollutants); Activation and/or suppression of lymphocyte reactions; Influence on cytokine expression.	See consequences.	Immunological dysfunction like hypersensitivity or immunosuppression; Changes in susceptibility to infection diseases.	Bennett et al., 2001; De Swart et al., 1996; Kakuschke et al., 2005; Kakuschke et al., 2006; Lalancette et al., 2003; Pillet et al., 2000; Ross, 2002; Siebert, et al., 1999
Cetaceans (15 different species)	Live stranding	*Vascular compromise?*	Accumulation of acute-phase proteins in hepatocytes; Acute liver congestion.	Unclear.	Godinho et al., 2005
Beluga	(Mutagenic) Pollutants	Activation and/or suppression of lymphocyte reactions; Consistent with GC and/or toxic effects of contaminants; Effects of mutagenic pollutants; PCB toxicology.	See consequences.	Immunological dysfunction in vitro & in vivo; Increase opportunistic bacterial infection; Adrenal cortex degeneration/proliferation; Cancer; CYP induction.	Buckingham, 2006; De Kloet et al., 1998; Escriva et al., 1997; Hahn, 2002; Herold, McPherson & Reichardt, 2006; Matsumara, 1995; McMillan et al., 2007; Remillard & Bunce, 2002; Wang et al., 2003; Williamson, Gasiewicz & Opanashuk, 2005

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
Eastern Tropical Pacific (ETP) dolphins	Purse-seine fishery (Acoustic cues associated with imminent capture attempt)	Set evasion.	Increased swim speed (2-3 m/sec); Leaping out of the water to breathe; Evasive maneuvering; Likely separation of mothers and young calves.	Energetic cost; Physiological stress response; School (social) disruption; Foraging disruption, Calf separation, Calf mortality, Capture myopathy.	Edwards, 2002, 2006; Myrick & Perkins, 1995; Noren & Edwards, 2007; Noren, Biedenbach & Edwards, 2006; NRC, 1992; Reilly et al., 2005; Weihs, 2004
ETP dolphins	Fishery capture	Wait for release.	Relatively calm milling and schooling in section of net far from vessel and close to section of net section where backdown channel will form.	Reduced net entanglement – therefore reduced in-net mortality; Interrupted social and foraging activities.	Edwards, 2002, 2006; Myrick & Perkins, 1995; Noren & Edwards, 2007; Noren, Biedenbach & Edwards, 2006; NRC, 1992; Reilly et al., 2005; Weihs, 2004
ETP dolphins	Release from purse-seine	Escape.	Prolonged (90 minutes) high speed (3-4 m/sec) escape swimming.	Energetic cost; Physiological stress response; School (social) disruption; Foraging disruption, Calf separation; calf mortality; Capture myopathy.	Edwards, 2002, 2006; Myrick & Perkins, 1995; Noren & Edwards, 2007; Noren, Biedenbach & Edwards, 2006; NRC, 1992; Reilly et al., 2005; Weihs, 2004
Harbor porpoise	Bycatch	*Suffocation?*	Accumulation of acute-phase proteins in hepatocytes; Death.	Death by suffocation.	Godinho et al., 2006
Marine mammals	Tonal/impulsive noise	Temporary Threshold Shift (TTS) in hearing.	TTS.	Compromised food-finding, navigation, and communication; Increased risk of predation	Finneran et al., 2002; Kastak et al., 1999; Schlundt et al., 2000
Cetaceans	Seismic surveys	*???*	Lower sighting rates; Avoidance of seismic array; Less feeding.	Energetic consequences.	Stone & Tasker, 2006
Coastal odontocetes	Chronic intermittent boat interactions	Flight response.	Behavioral budget alteration.	Reduced reproductive success; Decreased population viability; Habitat displacement.	Bejder, 2005; Bejder et al., 2006; Lusseau, 2004; Lusseau, Slooten & Currey, 2006

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
Coastal odontocetes	Boat interactions	Masking.	Reduce foraging time.	*Decreased survival rates?*	Erbe, 2002; Lusseau et al., submitted; Williams, Lusseau & Hammond, 2006
Small odontocetes	Seismic surveys	*???*	Faster swimming.	*Energetic consequences?*	Stone & Tasker, 2006
Bottlenose dolphins	Boat approach	*Masking of signals of interest for social communication and foraging?*	Higher whistling rate.	*Time/energy costs?* *Information ambiguity?*	Buckstaff, 2004
Beaked whales	Shipping noise	Masking of signals of interest for social communication and foraging.	High noise levels.	*Energetic consequences?* *Information ambiguity?*	Aguilar Soto et al., 2006
Beaked whales	Military exercises	Gas and fat embolism (hypothesis).	Atypical mass stranding (land and/or sea); Gas and fat embolic pathology.	Individual deaths; Possibly local population displacement or death.	Fernández et al., 2005; Jepson et al., 2003
Beaked whales	Shipping noise	*???*	*Activation of evasion mechanisms??*	Possible change in diving behaviour leading to reduction in foraging efficiency; Reduction in communication range.	Aguilar Soto et al., 2006
Killer whale	High boat traffic	*Masking of signals of interest for social communication and foraging?*	Increased call length.	*Time/energy costs?* *Information ambiguity?*	Foote, Osborne & Hoelzel, 2004
Killer whale	Acoustic Harassment Devicess	*???*	Long-term avoidance of area.	*Time/energy costs? Loss of opportunity for foraging, social interaction, mating?*	Morton & Symonds, 2002
Beluga	Boat noise	*Masking?*	Shifted frequencies; Used different call types.	Energetic/time/predator/prey costs; *Information ambiguity?*	Lesage et al., 1999
Beluga	Seismic like noise	*???*	Increased stress hormone levels.	*Immunity/illness consequences?*	Romano et al., 2004

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
Beluga	Icebreaker noise	*???*	Avoidance and flight at long ranges.	*Time/energy costs? Loss of opportunity for foraging, social interaction, mating?*	Cosens & Dueck, 1993; Finley et al., 1990
Pilot whales	MF sonar	*Masking?*	Increases in whistles.	*Time/energy costs?*	Rendell & Gordon, 1999
Sperm whales	Pingers	*???*	Fell silent.	*Compromised foraging or communication?*	Watkins & Schevill, 1975
Sperm whales	MF Sonar	*???*	Fell silent.	*Compromised foraging or communication?*	Watkins, Moore & Tyack, 1985
Sperm whales	Seismic surveys	*???*	Fewer creaks; No foraging dives near seismic vessel; Reduced fluke strokes and effort.	*Compromised foraging?*	IWC, 2007
Pilot, sperm whales	Low frequency pulses (similar to Acoustic Thermometry of Ocean Climate – ATOC – signals)	*???*	Decrease in vocalizations.	*Compromised foraging or communication?*	Bowles et al., 1994
Pilot, sperm whales	Seismic surveys	*???*	Decrease in vocalizations.	*Compromised foraging or communication?*	Bowles et al., 1994
Mysticetes	Seismic surveys	*???*	Avoidance; More time at surface; Fewer animals feeding.	*Time/energy costs? Reduced foraging?*	Stone & Tasker, 2006
Blue whales	Long range shipping noise	Masking.	Shifting frequency of call; May be some amplitude increase.	*Reduced mating opportunity?*	Croll et al., 2001; Payne & Webb, 1971
Fin whales	Seismic surveys	*???*	Suspension of vocalizations for weeks/months.	*Reduced mating opportunity?*	IWC, 2007
Fin whales	Boat noise	*???*	Decrease in vocalizations.	*Reduced mating opportunity?*	Watkins, 1986
Gray whales	Industrial noise, dredging and shipping	*???*	Long-term displacement of breeding area.	*Reduced mating opportunity?*	Bryant, Lafferty & Lafferty, 1984; Jones et al. 1994

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
Gray whales	Low frequency active (LFA) sonar (inshore)	*???*	Shift in migration path.	*Increased predation?* *Greater mother-calf/group separation??* *Anxiety?*	Tyack & Clark, 1988
Gray whales	Seismic surveys	*???*	Displacement out of primary feeding area; Faster respiration; Faster, straighter movement over larger areas.	*Reduced foraging?* *Time/energy costs?*	IWC, 2005, 2007
Gray whales and bowheads	Industrial noise	*???*	Shift in migration path.	*Increased predation?* *Greater mother-calf/group separation??* *Anxiety?*	Malme et al., 1983, 1984; Richardson et al., 1985; Richardson, Würsig & Greene, 1990
Bowheads	Seismic surveys	*???*	Shorter dives and lower respiration rates at as much as 50-70 km away.	*Widespread reduction in foraging?*	Richardson, Würsig & Greene, 1986
Humpbacks	LFA sonar	*???*	Mating songs lengthened.	*Long-term mating/energetic/time consequences?*	Fristrup, Hatch & Clark, 2003; Miller et al., 2000
Humpbacks	Seismic surveys	*???*	Avoidance; Occasional attraction prior to swimming away.	*Compromised foraging or breeding?*	McCauley et al., 2000
Humpbacks	Explosions	*???*	Greater entrapment in fishing gear	Often death.	Todd et al., 1996
Northern elephant seals	ATOC	*???*	Increased descent and decreased ascent rate in dives; Escape response.	*Reduced foraging?* *Time/energy costs?*	Costa et al., 2003

References for Appendix 1

Aguilar Soto, N., Johnson, N., Madsen, P. T., Tyack, P. L., Bocconcelli, A. & Borsani, J. F. (2006). Does intense ship noise disrupt foraging in deep-diving Cuvier's beaked whales (*Ziphius cavirostris*)? *Marine Mammal Science*, **22**(3), 690–699.

Babisch, W. (2000). Traffic noise and cardiovascular disease: Epidemiological review and synthesis. *Noise & Health*, **8**, 9-32.

Babisch, W. (2003). Stress hormones in the research on cardiovascular effects of noise. *Noise & Health*, **5**(18), 1-11.

Babisch, W. (2006). Transportation noise and cardiovascular risk: Updated review and synthesis of epidemiological studies indicate that the evidence has increased. *Noise & Health*, **8**(30), 1-29.

Baldwin, A. L. & Bell, I. R. (2007). Effect of noise on microvascular integrity in laboratory rats. *Journal of American Association for Laboratory Animal Science*, ***46***(1), 58-65.

Baldwin, A. L., Primeau, R. & Johnson, W. (2006). Effect of noise on the morphology of the intestinal mucosa in laboratory rats. *Contemporary Topics of Laboratory Animal Science*, **45**(1), 74-82.

Basner, M. & Samuel, A. (2005). Effects of nocturnal aircraft noise on sleep structure. *Somnologie*, **9**(2), 84-95.

Bateson, M. & Matheson, S. M. (2007). Removal of environmental enrichment induces 'pessimism' in captive European starlings (*Sturnus vulgaris*). *Animal Welfare*, **16**(S), 33-36.

Beale, C. M. & Monaghan, P. (2004a). Behavioural responses to human disturbance: A matter of choice? *Animal Behaviour*, **68**, 1065-1069.

Beale, C. M. & Monaghan, P. (2004b). Human disturbance: People as predation free predators? *Journal of Applied Ecology*, **41**, 335-343.

Bejder, L. (2005). *Linking Short and Long-Term Effects of Nature-based Tourism on Cetaceans*. Unpublished PhD, Dalhousie University, Halifax.

Bejder, L., Samuels, A., Whitehead, H., Gales, N., Mann, J., Connor, R. C., Heithaus, M. R., Watson-Capps, J., Flaherty, C. & Krutzen, M. (2006). Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology*, **20**(6), 1791-1798.

Bennett, P. M., Jepson, P. D., Law, R. J., Jones, B. R., Kuiken, T., Baker, J. R., Rogan, E. & Kirkwood, J. K. (2001). Exposure to heavy metals and infectious disease mortality in harbour porpoises from England and Wales. *Environmental Pollution*, **112**, 33-40.

Bowles, A. E., Smultea, M., Würsig, B., DeMaster, D. P. & Palka, D. (1994). Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. *Journal of the Acoustical Society of America*, **96**, 2469-2484.

Bryant, P. J., Lafferty, C. M., & Lafferty, S. K. (1984). Reoccupation of Guerrero Negro, Baja California, Mexico, by gray whales. In M. L. Jones, S. L. Swartz & S. Leatherwood (Eds.), *The Gray Whale*, Eschrichtius robustus (pp. 375-87). Orlando: Academic Press.

Buckingham, J. C. (2006). Glucocorticoids: Exemplars of multi-tasking. *British Journal of Pharmacology*, **147**, S258-268.

Buckstaff, K. C. (2004). Effects of watercraft noise on the acoustic behavior of bottlenose dolphins, *Tursiops truncatus*, in Sarasota Bay, Florida. *Marine Mammal Science*, **20**(4), 709-725.

Burwell, A.K. & Baldwin, A.L. (2006). Do audible and ultrasonic sounds of intensities common in animal facilities affect the autonomic nervous system of rodents. *Journal of Applied Animal Welfare Science*, **9**(3), 179-199.

Clark, C., Martin, R., van Kempen, E., Alfred, T., Head, J., Davies, H.W., Haines, M.M., Lopez Barrio, I., Matheson, M. & Stansfeld, S.A. (2006). Exposure-effect relations between aircraft and road traffic noise exposure at school and reading comprehension: The RANCH project. *American Journal of Epidemiology*, **163**, 27-37.

Cosens, S. E. & Dueck, L. P. (1993). Ice breaker noise in Lancaster Sound, NWT, Canada: Implications for marine mammal behavior. *Marine Mammal Science*, **9**(3), 285-300.

Costa, D. P., Crocker, D. E., Gedamke, J., Webb, P. M., Houser, D. S., Blackwell, S. B., Waples, S., Hayes, S. A. & LaBouef, B. J. (2003). The effect of a low-frequency sound source (acoustic thermometry of the ocean climate) on the diving behaviour of juvenile northern elephant seals, *Mirounga angustirostris. Journal of the Acoustical Society of America*, **113**(2), 1155-1165.

Croll, D. A., Clark, C. W., Calambokidis, J., Ellison, W. T. & Tershy, B. R. (2001). Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. *Animal Conservation*, **4**, 13-27.

De Kloet, E. R., Vreugdenhil, E., Oitzl, M. S. & Joëls, M. (1998). Brain Corticosteroid Receptor Balance in Health and Disease. *Endocrine Reviews*, **19**(3), 269-01.

De Swart, R. L., Ross, P. S., Vos, J. G., & Osterhaus, A. D. M. E. (1996). Impaired immunity in harbour seals (*Phoca vitulina*) exposed to bioaccumulated environmental contaminants: Review of a long-term feeding study. *Environmental Health Perspectives*, **104**, 823-828.

Deak, T., Bellamy, C. & D'Agostino, L. G. (2003). Exposure to forced swim stress does not alter central production of il-1. *Brain Research*, **972**, 53-63.

Edwards, E. F. (2006). Duration of unassisted swimming activity for spotted dolphin (*Stenella attenuata*) calves: Implications for mother-calf separation during tuna purse-seine sets. *Fishery Bulletin*, **104**, 125-135.

Edwards, E. F. 2002. *Energetics consequences of chase by tuna purse-seiners for spotted dolphins (*Stenella attenuata*) in the eastern tropical Pacific Ocean*. Administrative Report LJ-02-29, NMFS, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037. 45pp.

Erbe C. 2002. Underwater noise of whalewatching boats and potential effects on killer whales (Orcinus orca), based on an acoustic impact model. *Marine Mammal Science*, **18**, 394-418.

Escriva, H., Safi, R., Hänni, C., Langlois, M. C., Saumitou-Laprade, P., Stetehelin, D., Capron, A., Pierce, R. & Laudet, V. (1997). Ligand binding was acquired during evolution of nuclear receptors. *Proceedings of the National Academy of Sciences of the United States of America*, **94**, 6803-808.

Fernández, A., Edwards, J. F., Rodríguez, F., Espinosa de los Monteros, A., Herráez, P., Castro, P., Jaber, J. R., Martín, V. & Arbelo, M. (2005). "Gas and fat embolic syndrome" involving a mass stranding of beaked whales (family *Ziphiidae*) exposed to anthropogenic sonar signals. *Veterinary Pathology*, **42**, 446-457.

Finley, K. J., Miller, G. W., Davis, R. A. & Greene, C. R. (1990). Reactions of belugas, *Delphinapterus leucas*, and narwhals, *Monodon monoceros*, to ice-breaking ships in the Canadian high arctic. *Canadian Bulletin of Fisheries and Aquatic Sciences*, **224,** 97-117.

Finneran, J. J., Schlundt, C. E., Dear, R., Carder, D. A. & Ridgway, S. H. (2002). Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *Journal of the Acoustical Society of America*, **111**(6), 2929–2940.

Foote, A.D., Osborne, R.W., & Hoelzel, A. R. (2004). Whale-call response to masking boat noise. *Nature (London)*, **428**, 910.

Fristrup, K. M., Hatch, L. T. & Clark, C. W. (2003). Variation in humpack whale (*Megaptera novaengliae*) song length in relation to low-frequency sound broadcasts. *Journal of the Acoustical Society of America*, **113**, 3411–3424.

Fuller, R. A., Warren, P. H. & Gaston, K. J. (2007). Daytime noise predicts nocturnal singing in urban robins. *Biology Letters*, **3**(4), 368-370.

Godinho, A., Jepson, P., Deville, R., Castro, P., Jaber, J. & Fernández, A. (2006). Intracytoplasmic eosinophilic globules in hepatocytes of by-caught harbour porpoises (*Phocoena phocoena*). *Poster Presentation at the 20th Annual Meeting of the European Cetacean Society*. Gdynia, Poland.

Godinho, A., Monti, G., Arbelo, M., Silvosa, M., Sierra, E., Castro, P., Jaber, J., Rodríguez, F. & Fernández, A. (2005). Intracytoplasmic eosinophilic globules in hepatocytes of stranded cetaceans in the Canary Islands. *Poster Presentation at the 19th Annual Meeting of the European Cetacean Society*. La Rochele, France.

Hahn, M.E. (2002). Aryl hydrocarbon receptors: Diversity and evolution. *Chemico-Biological Interactions*, **141**, 131-60.

Haines, M.M., Stansfeld, S.A., Brentnall, S., Head, J., Berry, B., Jiggins, M. & Hygge, S. (2001). The West London Study: The effects of chronic aircraft noise exposure on child health. *Psychological Medicine*, **31**, 1385-1396.

Haines, M.M., Stansfeld, S.A., Job, R.F.S., Berglund, B. & Head, J. (2001). Chronic aircraft noise exposure, stress responses, mental health and cognitive performance in school children. *Psychological Medicine*, **31**, 265-277.

HCN – The Health Council of the Netherlands. (2004). *The influence of night-time noise on sleep and health*. The Hague: Health Council of the Netherlands. Publication No. 2004/14E.

Hennessy, M. B., Schiml-Webb, P. A., Miller, E. E., Maken, D. S., Bullinger, K. L. & Deak, T. (2007). Anti-inflammatory agents attenuate the passive responses of guinea pig pups: Evidence for stress-induced sickness behavior during maternal separation. *Psychoneuroendocrinology*, **32**(5), 508-515.

Herold, M. J., McPherson, K. G. & Reichardt, H. M. (2006). Glucocorticoids in T cell apoptosis and function. *Cellular and Molecular Life Sciences*, **63**, 60-72.

Hiramatsu, K., Minoura, T., Matsui, T., Miyakita, T., Osada, Y. & Yamamoto, T. (2000). An analysis of the general health questionnaire survey around airports in terms of annoyance reaction. *Proceedings of the 29th International Congress on Noise Control Engineering*, vol 4, pp 2089-2093, Nice, France: Inter-noise 2000.

Hygge, S., Evans, G. W. & Bullinger, M. (2002). A prospective study of some effects of aircraft noise on cognitive performance in school children. *Psychological Science*, **13**(5), 469-474.

IWC – International Whaling Commission. (2005) Report of the scientific committee. Annex K. Report of the Stranding Working Group on environmental concerns. *Journal of Cetacean Research and Management*, **7**(S), 267-305.

IWC – International Whaling Commission. (2007) Report of the scientific committee. Annex K. Report of the Stranding Working Group on environmental concerns. *Journal of Cetacean Research and Management*, **9**(S), 227-296.

Jepson, P. D., Bennett, P. M., Deaville, R., Allchin, C. R., Baker, J. R. & Law, R. J. (2005). Relationships between polychlorinated biphenyls and health status in harbor porpoises (*Phocoena phocoena*) stranded in the United Kingdom. *Environmental Toxicology and Chemistry*, **24**, 238-248.

Jones, M. L., Swartz, S. L. & Dahlheim, M. E. (1994). *Census of Gray Whale Abundance in San Ignacio Lagoon: a Follow-Up Study in Response to Low Whale Counts Recorded During an Acoustic Playback Study of Noise Effects on Gray Whales*. Report to the U.S. Marine Mammal Commission, Washington, DC. NTIS PB94195062. 32 pp.

Kakuschke, A., Valentine-Thon, E., Fonfara, S., Griesel, S., Siebert, U. & Prange, A. (2006). Metal sensitivity of marine mammals: A case study of a gray seal (*Halichoerus grypus*). *Marine Mammal Science*, **22**, 985-996.

Kakuschke, A., Valentine-Thon, E., Griesel, S., Fonfara, S., Siebert, U. & Prange, A. (2005). Immunological impact of metals in harbor seals (*Phoca vitulina*) of the North Sea. *Environmental Science & Technology*, **39**, 7568-7575.

Kastak, D., Schusterman, R. J., Southall, B. L. & Reichmuth, C. J. (1999). Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. *Journal of the Acoustical Society of America*, **106**(2), 1142-1148

Lalancette, A., Morin, Y., Measures, L. & Fournier, M. (2003). Contrasting changes of sensitivity by lymphocytes and neutrophils to mercury in developing grey seals. *Developmental and Comparative Immunology*, **27**, 735-747.

Lercher, P., Evans, G. W., Meis, M. & Kofler, W. W. (2002). Ambient neighbourhood noise and children's mental health. *Occupational and Environmental Medicine*, **59**, 380-386.

Lesage, V., Barrette, C., Kingsley, M. C. S. & Sjare, B. (1999). The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence River Estuary, Canada. *Marine Mammal Science*, **15**(1), 65-84.

Lusseau, D., Bain, D. E., Williams, R. & Smith, J. C. submitted. Vessel traffic disrupts foraging behaviour of southern resident killer whales (*Orcinus* sp.). *Endangered Species Research*.

Lusseau, D. (2004). The hidden cost of tourism: detecting long-term effects of tourism using behavioral information. *Ecology and Society*, **9**(1), 2.

Lusseau, D., Slooten, E. & Currey, R. J. (2006). Unsustainable dolphin watching activities in Fiordland, New Zealand. *Tourism in Marine Environments*, **3**(2), 173-178.

Mallord, J. W., Dolman, P. M., Brown, A. F. & Sutherland, W. J. (2007). Linking recreational disturbance to population size in a ground-nesting passerine. *Journal of Applied Ecology*, **44**, 185–195.

Malme, C. I., Miles, P. R., Clark, C. W., Tyack, P. & Bird, J. E. (1983). *Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior*. Report of Bolt Beranek & Newman, Inc., Cambridge, MA, to U.S. Minerals Management Service, Anchorage. NTIS PB86-174174.

Malme, C. I., Miles, P. R., Clark, C. W., Tyack, P. & Bird, J. E. (1984). *Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior. Phase II: January 1984 Migration*. Report of Bolt Beranek & Newman, Inc., Cambridge, MA, to U.S. Minerals Management Service, Anchorage. NTIS PB86-218377.

Matheson, S. M., Asher, L. & Bateson, M. (2008). Larger, enriched cages are associated with 'optimistic' response biases in captive European starlings (*Sturnus vulgaris*). *Applied Animal Behavior Science*, **109**, 374-383.

Matsumura, F. (1995). Mechanism of action of dioxin-type chemicals, pesticides, and other xenobiotics affecting nutritional indexes. *American Journal of Clinical Nutrition*, **61,** 695S-701S.

McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M. N., Penrose, J., Prince, R. I. T., Adhitya, A., Murdoch, J. & McCabe, K. (2000). Marine seismic surveys: A study of environmental implications. *APPEA Journal*, **40**, 692-708.

McEwen B. S. & Goodman H. M. (Eds.)(2001). *Handbook of Physiology; Section 7: The Endocrine System; Volume IV: Coping with the Environment: Neural and Endocrine Mechanisms*. New York: Oxford University Press. 562pp.

McMillan, B. J., McMillan, S. N., Glover, E. & Bradfield, C. A. (2007). 2,3,7,8-Tetrachlorodibenzo-p-dioxin Induces Premature Activation of the KLF2 Regulon during Thymocyte Development. *The Journal of Biological Chemistry*, **282**(17), 12590–12597.

Midema, H. M. E. & Vos, H. (2007). Associations between self-reported sleep disturbance and environmental noise based on reanalyses of pooled data from 24 studies. *Behavioral Sleep Medicine*, **5**(1), 1-20.

Miller, P. J. O., Biasson, N., Samuels, A. & Tyack, P. L. (2000). Whale songs lengthen in response to sonar. *Nature (London)*, **405**, 903.

Mooney, N. J. & Holdsworth, M. (1991). The effects of disturbance on nesting wedge-tailed eagles in Tasmania. *Tasforests*, **3**, 15-32.

Mooney, N. J. & Taylor, R. (1996). Value of nest site protection in ameliorating the effects of forestry operations on wedge-tailed eagles in Tasmania. In D. M. Bird, D. E. Varland & J. J. Negro (Eds.), *Raptors In Human Landscapes: Adaptations to Built and Cultivated Environments*. Raptor Research Foundation. London: Academic Press. 396 pp.

Morton, A. B. & Symonds, H. K. (2002). Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia. *ICES Journal of Marine Sciences*, **59**, 71-80.

Myrick, A. C. & Perkins, P. C. (1995). Adrenocortical color darkness as indicators of continuous premortem stress in chased and purse-seined male dolphins. *Pathophysiology*, **2**, 91-204.

Nguyen, K. T., Deak, T., Owens, S. M., Kohno, T., Fleshner, M., Watkins, L. R. & Maier, S. F. (1998). Exposure to acute stress induces brain interleukin -1b protein in the rat. *Journal of Neuroscience*, **18**(6), 2239-2246.

Noren, S. R. & Edwards, E. F. (2007). Physiological and behavioral development in delphinid calves: Implications for calf separation and mortality due to tuna purse-seine sets. *Marine Mammal Science*, **23**(1), 15-29.

Noren, S. R., Biedenbach, G. & Edwards, E. F. (2006). Ontogeny of swim performance and mechanics in bottlenose dolphins (Tursiops truncatus). *Journal of Experimental Biology*, **209**, 4724-4731.

NRC – U.S. National Research Council. (1992). *Dolphins and the Tuna Industry/Committee on Reducing Porpoise Mortality from Tuna Fishing*. Washington, DC: National Academy Press. 176pp.

Payne, R. & Webb, D. (1971). Orientation by means of long range acoustic signaling in baleen whales in: Orientation: Sensory basis. *Annals of the New York Academy of Sciences*, **188**, 110-142.

Pillet, S., Lesage, V., Hammill, M., Cyr, D. G., Bouquegneau, J. M. & Fournier, M. (2000). *In vitro* exposure of seal peripheral blood leukocytes to different metals reveal a sex-dependent effect of zinc on phagocytic activity. *Marine Pollution Bulletin*, **40**, 921-927.

Plata-Salaman, C. R., Ilyin, S. E., Turrin, N. P., Gayle, D., Flynn, M. C., Bedard, T., Merali, Z. & Anisman, H. (2000). Neither acute nor chronic exposure to a naturalistic (predator) stressor influences the interleukin-1beta system, tumor necrosis factor-alpha, transforming growth factor-beta1, and neuropeptide mrnas in specific brain regions. *Brain Research Bulletin*, **51**(2), 187-193.

Reilly, S. B., Donahue, M. A., Gerrodette, T., Forney, K., Wade, P., Ballance, L., Forcada, J., Fiedler, P., Dizon, A., Perryman, W., Archer, F. A. & Edwards, E. F. (2005). *Report of the Scientific Research Program Under the International Dolphin Conservation Program Act*. National Oceanic and Atmospheric Administration, National Marine Fisheries Service Technical Memorandum NOAA-TM-NMFS-SWFSC-372. La Jolla, CA: Southwest Fisheries Science Center. 100 pp. Available at: http://swfsc.noaa.gov/publications/tm/swfsc/noaa-tm-nmfs-swfsc-372.pdf.

Remillard, R. B. J. & Bunce, N. J. (2002). Linking Dioxins to Diabetes: Epidemiology and Biologic Plausibility. *Environmental Health Perspectives*, **110,** 853-858.

Rendell, L. E. & Gordon, J. C. D. (1999). Vocal response of long-finned pilot whales (*Globicephala melas*) to military sonar in the Ligurian Sea. *Marine Mammal Science*, **15**(1), 198-204.

Richardson, W. J., Fraker, M. A., Würsig, B. & Wells, R. S. (1985). Behavior of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: Reactions to industrial activities. *Biological Conservation*, **32**(3), 195-230.

Richardson, W. J., Würsig, B. & Greene, C. R., Jr. (1986). Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. *Journal of the Acoustical Society of America*, **79**(4), 1117-1128.

Richardson, W. J., Würsig, B. & Greene, C. R., Jr. (1990). Reactions of bowhead whales, *Balaena mysticetus*, to drilling and dredging noise in the Canadian Beaufort Sea. *Marine Environmental Research*, **29**(2), 135-160.

Romano, T. A., Keogh, M. J., Kelly, C., Feng, P., Berk, L., Schlundt, C. E., Carder, D. A. & Finneran, J. J. (2004). Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. *Canadian Journal of Fisheries and Aquatic Sciences*, **61**, 1124-1134.

Ross, P. S. (2002). The role of immunotoxic environmental contaminants in facilitating the emergence of infectious diseases in marine mammals. *Human and Ecological Risk Assessment*, **8**, 277-292.

Sapolsky, R. M., Romero, L. M., Munck, A. U. (2000). How do glucocorticoids influence stress-responses? Integrating permissive, suppressive, stimulatory, and adaptive actions. *Endocrine Reviews*, **21**, 55-89.

Schlundt, C. E., Finneran, J. J., Carder, D. A. & Ridgway, S. H. (2000). Temporary shift in masked hearing thresholds (MTTS) of bottlenose dolphins and white whales after exposure to intense tones. *Journal of the Acoustical Society of America*, **107**, 3496-3508.

Shintani, F. S., Nakaki, T., Kanba, S., Kato, R. & Asai, M. (1995). Role of interleukin-1 in stress responses: A putative neurotransmitter. *Molecular Neurobiology*, **10**, 47-71.

Siebert, U., Joiris, C., Holsbeek, L., Benke, H., Failing, K., Frese, K. & Petzinger, E. (1999). Potential relation between mercury concentrations and necropsy findings

in cetaceans from German waters of the North and Baltic Seas. *Marine Pollution Bulletin*, **38**, 285-295.

Stansfeld, S. A., Berglund, B., Clark, C., Lopez Barrio, I., Fischer, P., Öhrström E., Haines, M. M., Head, J., Hygge, S., van Kamp, I. & Berry, B. F. (2005). Aircraft and road traffic noise and children's cognition and health: A cross-national study. *The Lancet*, **365**, 1942-1949.

Stone, C. J. & Tasker, M. L. (2006). The effect of seismic airguns on cetaceans in UK waters. *Journal of Cetacean Research and Management*, **8**(3), 255-263.

Todd, S., Stevick, P., Lien, J., Marques, F. & Ketten, D. (1996). Behavioural effects to underwater explosions in humpback whales (*Megaptera novaeangliae). Canadian Journal of Zoology*, **74**, 1661-1672.

Tyack, P. L. & Clark, C. W. (1998). *Quick-Look Report: Playback of Low-Frequency Sound to Gray Whales Migrating Past the Central California Coast*. Unpublished Report. Available from the National Marine Mammal Laboratory (nmml.library@noaa.gov).

van Kempen, E. E. M. M., Kruize, H., Boshuizen, H. C., Ameling, C. B., Staatsen, B. A. M. & de Hollander, A. E. M. (2002). The association between noise exposure and blood pressure and ischemic heart disease: A Meta-analysis. *Environmental Health Perspectives*, **110**(3), 307-317.

Wang, H., Faucette, S. R., Gilbert, D., Jolley, S. L., Sueyoshi, T., Negishi, M. & Lecluyse, E. L. (2003). Glucocorticoid receptor enhancement of pregnane X receptor-mediated CYP2B6 regulation in primary human hepatocytes. *Drug Metabolism & Disposition*, **31**(5), 620-630.

Watkins, W. A. & Schevill, W. E. (1975). Sperm whales (*Physeter catodon*) react to pingers. *Deep-Sea Research*, **22**, 123-129.

Watkins, W. A. (1986). Whale reactions to human activities in Cape Cod waters. *Marine Mammal Science*, **2**, 251-262.

Watkins, W. A., Moore, K. E. & Tyack, P. (1985). Sperm whale acoustic behaviors in the southeast Caribbean. *Cetology*, **49**, 1-15.

Weihs, D. (2004). The Hydrodynamics of Dolphin Drafting. *Journal of Biology*, **3**(2), 801-815.

Williams, R., Lusseau, D. & Hammond, P. S. (2006). Estimating relative energetic costs of human disturbance to killer whales (*Orcinus orca*). *Biological Conservation*, **133**(3), 301-311.

Williamson, M. A., Gasiewicz, T. A. & Opanashuk, L. A. (2005). Aryl Hydrocarbon Receptor Expression and Activity in Cerebellar Granule Neuroblasts: Implications for Development and Dioxin Neurotoxicity. *Toxicological Sciences*, **83,** 340-348.

Windle, R. J., Wood, S. A., Lightman, S. L. & Ingram, C. D. (1998). The pulsatile characteristics of hypothalamo-pituitary-adrenal activity in female Lewis and Fischer 344 rats and its relationship to differential stress responses. *Endocrinology*, **139**(10), 4044-4052.

ITP Goldstein <itp.goldstein@noaa.gov>

stop Diablo Canyon Testing

J T <mythic111@gmail.com> Tue, Oct 16, 2012 at 2:01 PM
To: ITP.Goldstein@noaa.gov, Howard.Goldstein@noaa.gov

Dear Sir,

I am urging you as a fourth generation native Californian to stop the Diablo Canyon testing. We must preserve our aquatic resources. Our mammals are part of our heritage. This unconscionable and unnecessary cruelty must stop.

As citizens of the state, country and planet, we must take responsabilty for actions and prevent their dangerous side effects. Contmplating safe and effective means of testing and research is of utmost importance at this time in history.

Thank you for your time and attention.

J. A. Tucker

ITP Goldstein <itp.goldstein@noaa.gov>

dont kill marine mamals !!!

Jean-Michel <jm@byoc.org> Mon, Oct 15, 2012 at 2:40 AM
To: ITP.Goldstein@noaa.gov

Hello

please dont kill marine mamals !!!

--

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL # of pages ▸ 4

To Howard Goldstein	From Monica DeAngelis
Dept./Agency CCC	Phone # 562-980.3232
Fax # 415.713.0376	Fax # 562.980.4659

NSN 7540-01-317-7368 5099-101 GENERAL SERVICES ADMINISTRATION

California Coastal Commission
Energy, Ocean Resources and
Federal Consistency Division
45 Fremont St., Suite 2000
San Francisco, Ca 94105

My family and I are astonished that a legislative order to use Sonic Blasting for the seismic measuring of earthquake faults off the shores of California has been approved by the State Lands Commission and that PG&E are considering the execution of such! With the known devastation and harm to ALL SEA LIFE within 100 miles of these blasts--the deafening, and subsequent death of these innocent and native species---is NO SANE compromise for the relicensing of Diablo Nuclear Power Plant, nor for the sake of "public safety".

We, as humanity, have come to a defining point in our collective consciousness that will expose our integrity, or our blind disregard, of Life---due to our empty heart. We are counting on The CA Coastal Commission, NOAA and National Marine Fisheries Services to prohibit the further use of Seismic (Sonic) Blasting as a method to measure the depth and breadth of faults adjacent to our power plants. This action will contradict the Endangered Species Act and the International Oceans Management Treaty and sacrifice multitudes of species that we regard as an integral part of our community.

Mothers For Peace has claimed that they are not opposed to seismic testing, as long as the means is appropriate for all concerned. Many that I encountered during our C.O.A.S.T Alliance petition drive, on Harbor Day 2012, in Morro Bay, felt the same way. Most were weary of the role that Diablo Nuclear Power Plant posed for our community, with regard to its costs in subsidies, the altering of our environment (larvae, heat, impending devastation), and with regard to the problems of storage of spent fuel. We would appreciate the said plant NOT being allowed to continue to operate, here on these 13 fault lines, and adjacent to sensitive ecosystems. It should be shut down and the dismantling process begun. Nuclear power is a very expensive and hazardous way of making steam.

The US Navy could possibly have mapping of this area. Their sonic scanning has also been shown to beach whales and porpoises. Your jurisdiction can serve to apprehend this unjust governmental "precaution" from happening.

We thank you for your service to our wonderful state of California,

Jeannine Jacobs
Earth Awake

Jeannine Jacobs

PETITION TO STOP SEISMIC TESTING IN THE CENTRAL COAST

The C.O.A.S.T. (Citizens Opposing Acoustic Seismic Testing) Alliance, a diverse coalition of individuals, associations and government and non-government organizations is unified in the goal of ending any efforts to permit high intensity acoustic seismic testing by PG&E in the regions surrounding the Diablo Canyon Power plant on the central coast of California.

Name	Signature	City	Address
Joshua Douglas		San Luis Obispo	2040 Rachel street. SLO CA 93401
Pete. Evans		SLO	2040 Rachel St.
Paul Grafton		Morro Bay	2450 Ironwood. Ave
Richard Sadowski		Morro Bay	490 Java ST.
Carson Eve		SLO	1
Karen Singer		Reno, Nevada	447 Aspen St.
Melinda Kenda		Morro Bay Ca	330 Arcadia Ave
Mike Jones		Morro Bay	1140 Front st
Courtney Carlson		Grover Beach, CA	1477 W. Grand Ave #12 93433
John Kassnerk		Grover Beach	1477 W Grand Ave #12 GB 93433
Nathan Paulson		SLO	58 O'Connor Way
Marlene Regan		Morro Bay	3030 Beach Canyon
Amanda Varner		Atascadero	5285 Ensenada
Nicholas Varner		Atascadero	5285 Ensenada
Ron Armstrong		Morro Bay	P.O. Box 576 Morro Bay CA
Helene Bailey		Atascadero	4420 Rosita Ave.
Misael Ingles		Bakersfield	460 Royal way
Megan Dawson		Bakersfield	" "
Clayton Gray		Morro Bay	520 Morro Bay Calif.
Anastasia Terris		Los Osos, CA	1351-R Los Olivos Ave.

PETITION TO STOP SEISMIC TESTING IN THE CENTRAL COAST

The C.O.A.S.T. (Citizens Opposing Acoustic Seismic Testing) Alliance, a diverse coalition of individuals, associations and government and non-government organizations is unified in the goal of ending any efforts to permit high intensity acoustic seismic testing by PG&E in the regions surrounding the Diablo Canyon Power plant on the central coast of California.

Name	Signature	City	Address
Deanna Shannon	Deanna Shannon	Los Osos	440 Manzanita Dr.
Shayla Balentine	Shayla Balentine	Cayucos	2865 Ocean Blvd.
Garnett Bell	[illegible]	Cayucos	2865 Ocean
Kenneth Oates			
Ken DUTRA	Kenneth Oates	SLO	365 Buchon SLO CA
Daya Richardson	Daya Richardson	Morro Bay	208 Shasta.
Kristen Osinaga	[illegible]	A.G!	153 S Elm st. #A 93420
Emma Jeffries	Emma Jeffries	Los Osos	1367 4th st
Marissa Jones	[illegible]	Los Osos	429 Arbutus Ave
Barb Ignatius	[illegible]	Morro Bay	2262 Indigo Cir
Kelsey Day	[illegible]	Cambria	1231 Pineridge Dr.
Alex Karol	[illegible]	CAMBRIA	1231 Pineridge Dr
Zarina Hackney	Zarina Hackney	San Luis Obispo	1262 Murray Ave.
Ginger Lashr	[illegible]	Grover Beach	564 Seabright
David Jeffries	[illegible]	Los Osos	1367 4th St.
Linda Teague	Linda Teague	Cayucos	3259 Ocean Blvd.
Michael TEAGUE	[illegible]	CAYUCOS	3259 Ocean Blvd
Bonnie Saucedo	Bonnie Saucedo	Morro Bay	473 Bernardo Ave.
Nancy Albee	[illegible]	Cayucos	3323 Shearer Ave
Kathy Kennedy	Kathy Kennedy	Los Osos	1248 17th St, L.O. 93402

PETITION TO STOP SEISMIC TESTING IN THE CENTRAL COAST

The C.O.A.S.T. (Citizens Opposing Acoustic Seismic Testing) Alliance, a diverse coalition of individuals, associations and government and non-government organizations is unified in the goal of ending any efforts to permit high intensity acoustic seismic testing by PG&E in the regions surrounding the Diablo Canyon Power plant on the central coast of California.

Name	Signature	City	Address
Katelyn Burlason	Katelyn Burlason	San Luis Obispo	593 Luneta Dr.
Tim Bottoms	TB	San Luis Obispo	P.O. Box 15559 93406
C Miller	C Miller		St Augustine Fl
Elaine Frawer	Elaine B Frawer	Morro Bay	480 Whitley Way
Damon Hall	[illegible]	SLO	691 Henderson
Kristi Nunes	Kristi Nunes	SLO	1685 Pereira
Clint Nunes	Clint N	SLO	1685 Pereira Dr
Riley Hitchcock	[illegible]	SLO	661A Sandercock St.
Christie Mosby	[illegible]	Los Osos	1060 Monterey #C MB
Geoffrey Hall	[illegible]	SLO	661A Sandercock St.
Becca Palerano	[illegible]	SLO	392 Foothill Dr.
James Raney	[illegible]	SLO	165 Chorro St.
Grant Williams	[illegible]	SLO	165 Chorro St.
Damon Bell	[illegible]	SLO	Foothill Rd
CARI MEISSNER	[illegible]	SLO	390 LAWRENCE DR
Aimee Wyatt	[illegible]	SLO	"
Caitrin Doles	[illegible]	SLO	392 Foothill blvd
Austin Bertucci	[illegible]	SLO	392 Foothill
Paige Kromhout	[illegible]	SLO	392 E. Foothill Blvd.
Bobbi Prima	[illegible]	M. B.	416 Tulare Ave.

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

jeff wefferson <therockist@gmail.com> Sun, Oct 14, 2012 at 3:20 PM
To: ITP.Goldstein@noaa.gov

TO: P. Michael Payne, Chief, Permits and Conservation Division,
Office of Protected Resources, National Marine Fisheries Service

DEAR MR. PAYNE...I am writing you on behalf of the cetaceans of Mother Earth, the pelagic marine mammals who are under attack the world over from human military-industrial activity, specifically, seismic geophysical exploration for hydro-carbon and mineral resources, sonar and war-games by the U.S. Navy, the testing and deployment of 'new generation' microwave weapons systems like HAARP and related technologies, and also by the astronomical contamination of the Pacific ocean by synthetic radio-nuclides from Fukushima. The U.S. Navy is the common denominator in all of these attacks. The U.S. Navy basically owns and operates both NOAA and NMFS, as well as 'research' institutes like Scripps and Woods Hole. The U.S. Navy controls approximately 98% of all 'marine biology' research, and they are also THE single largest nuclear entity on the planet, operating several hundred reactors.

You are just a bureaucrat doing what their higher-ups tell them to do, this I am aware of. These 'petitions' and 'environmental impact statements' and 'public inquiries' mean absolutely nothing because the whole global situation runs on money. The navy and energy corporations are going to do whatever they please, regardless of what anyone says or does.

I am writing this to you because you are a human being and you can choose to be or not to be a part of the literal 'genocide' of our fellow beings in the sea. YOU can stop choosing to work for the 'enemy', and YOU can choose to stop driving a car, because every time we drive, we are supporting the war on cetaceans and the war on life.

Attached is an article on all this that is running in the current issue of Uncensored magazine on stands across NZ, Australia and the UK.

And here is a link to my blog about the whales and dolphins:

http://tutununi-wananga.blogspot.com

cheers jeff wefferson

UNCENSORED 29 Wefferson.pdf
619K

‘WE ARE NOT ALONE...YET’

How We Are Waging War On A True ‘Extra-Terrestrial Intelligence’

by Jeff Wefferson

"I think that the cetaceans are using their highly advanced ‘internal technologies’ of group-telepathy and holographic consciousness-transmission to beam their love and message into the human psyche, now more than ever...Within their collective psyche they may have memories and knowledge of the history of Earth and humanity that we are unable and/or unwilling to access. They may have knowledge of life elsewhere in the universe…of telepathically-connected galactic communities…and a greater appreciation of the beauty and uniqueness of life on THIS planet. Perhaps they are the ‘mind of Gaia’ herself." MORE: http://tutunui-wananga.blogspot.com.au/2012/08/we-are-not-aloneyet-how-we-are-waging.html

INTRODUCTION

Modern man believes that he is ‘alone’ in the universe, yet nothing could be further from the truth. The mind-set of ‘civilized’ western humanity takes for granted that our collective world-view, the human perspective on life on Earth, represents the pinnacle of awareness, the paragon of ‘intelligence’, that we are sine pari, “without equal” in the kingdoms of life, above and apart from mere ‘animals’ and other ‘lower’ life-forms. This unquestioned anthropocentric ‘meta-belief’, the central pillar supporting the dominant dMOE(1), or ‘distributed mental operating environment’ which facilitates our fundamentally Judaeo-Christian neo-Darwinian military-industrial-capitalist ‘way of life’, justifies ecocide, rationalizes genocide, glorifies predation, rewards greed, derides simplicity, denies indigenous and alternative modes of being, and is conducting a full-spectrum jihad against life itself.

We have never been ‘alone.’ In the same way that we needn’t ‘go into space’ because we’re already there…how could we NOT be?...we’ve never been alone because our true ‘family’ is the universe, which as currently conceived may host not only a very broad spectrum of ‘beings’, ‘intelligences’ and forms of consciousness…of far greater diversity, improbability and unknowability than the sum of all science-fiction…but is ‘intelligent’ and ‘conscious’ in and of itself. Our nearest star, the sun, Sol, is a powerful stellar ‘being’ and ‘intelligence’; Mothership Earth, or Gaia, is herself an astronomically complex planetary ‘being’ and ‘intelligence’. The union of Father Sky and Mother Earth gives birth to life as we know her, a vast creative and experimental intelligence based on DNA, carbon compounds, and water who manifests herself as an endless expression of living art-information. Every being, every form of life is by nature ‘intelligent’ in its own way.(2) Humanity seems to be an anomaly on this planet: we are the only species among billions who have run amok and are actively destroying our home (3), as well as the only species who is embedded in collective hallucination, harbouring destructive delusions about our own alleged and superior ‘intelligence’ and other ‘chosen species’ fantasies.(4)

The cetaceans, the whales and dolphins, have lived in the ocean of Earth for tens of millions of years, according to our consensus model of time, and represent a vast supra-human ‘intelligence’ akin to our own in fundamental ways, yet truly ‘alien’ beyond comparison in equally fundamental ways. They have been here ten times longer than we have, with neuro-biological ‘internal technology’(5) far in advance of ours, living in far greater harmony with the more supportive and protective environment they inhabit. The breadth, depth and quality of their ‘reality’, their experience and ‘management’ of dimensions we refer to as ‘time’, ‘space’, ‘awareness’, ‘memory’, and ‘knowledge’ may exceed ours by several orders of magnitude. Their inner life is a vast unknown to us; if and when we become capable of comprehension, we may find their ‘reality’ to be far more expansive, far more ‘beautiful’ than anything we pretend to access."

CONTINUED NEXT PAGE ...

ANIMALS VERSUS 'PEOPLE' – The Real Case for Cetaceans

by Jeff Wefferson

Human views on things they don't understand tend to be riddled with romanticism and exploitation, and the cetaceans are no exception. Exploring the human relationship with the animal kingdom is an immense topic which includes the subjects of 'animal intelligence', 'inter-species communication', shamanism, 'conservation', pets, hunting, farming, and meat.(35) The human relationship with cetaceans unfortunately includes all of these.

What is the difference between an animal and a 'person'? We look for correspondences with our own perceived characteristics, our 'personhood'; awareness more than intelligence is the defining quality. Cetaceans are "intensely conscious of what they are doing…in exquisitely specific and finely detailed ways…they know what they are doing…their actions are purposeful, and stunningly specific to the occasion…they intend us no harm…they are aware." (36)

For a very long time I have believed that not only are the cetaceans equally if not more 'highly evolved' than humans, that in the world of today, they qualify as 'people' far more than do most human beings.

We must draw a distinction between two major 'factions' of humanity, a generalized division that is based not on biology but on psychology, not on genetics and anatomy but on different 'dMOE's' or 'distributed mental operating environments'…very different modes of being on Earth: indigenous/spiritual/ecological and modern/capitalist/materialist.(37)

This schism in human modes of being along with true awareness of cetaceans has led me to conclude that not only are they a TETI, or true 'extra-terrestrial intelligence', they are also TULIP's, the 'ultimate indigenous people.' Cetaceans have all the fundamental qualities of indigenous peoples, and are actually the 'next level' moving towards a totally 'non-material' and even 'spiritual' culture. In this way alone they are light-years ahead of homo sapiens, 'man, the wise'.

Behavioural scientists, conservation biologists, environmental capitalists and New Age gurus would all have us believe that cetaceans are 'worth saving' or even 'very special', but they can't explain why. Their attitudes and beliefs range from 'endangered populations' to 'magnificent creatures' to 'beautiful animals' to 'mystical beings' from another planet.(38) ALL of this is based on various forms of the exploitation that has always characterized the human relationship with cetaceans; and NONE of this has ANYTHING to do with who they really are as fellow sentient beings.

Cetaceans are BIG BUSINESS, and 'who' they are doesn't matter, or may even get in the way. Not only is whaling not a thing of the past, some of the world's most 'advanced' nations continue to condone and engage in this obvious barbarity, based on the insatiable human hunger for meat, which to me is one of biggest 'lead weights of karma' holding back our spiritual advancement. Sure, many indigenous peoples have traditionally hunted animals for food, and 'back in the day' that made sense and was spiritually and ecologically sound; that 'day', however, is long gone, and eating meat of any kind in today's world is unnecessary and dangerous. Why do Japan, Iceland, Norway and now even the United States have to keep practicing what is truly a form of mass-murder of our fellow beings?(39)

People like Captain Paul Watson of Sea Shepherd and Louis Psihoyos of Ocean Preservation Society have created much public awareness of these practices, not only through 'direct intervention' 'eco-activism' but primarily through mass-media, with Watson's 'Whale Wars' show on Discovery Channel's Animal Planet, and Psihoyos' movie 'The Cove.' On the surface, the message is clear: "evil Japanese are murdering innocent cetaceans, and this is the BIGGEST threat to their well-being that exists on the planet. SO GIVE US YOUR MONEY." Since becoming a television celebrity, Watson/Sea Shepherd's integrity has taken a nose-dive, and is now riddled with fraud and scandal. Psihoyos is a close second, having transformed his original 'documentary' into a 'staged reality fest' designed more for banking than cetaceans.(40) The bottom-line is that these people are exploiting both cetaceans and the human public and taking in vast sums of money as 'non-profit' organizations, yet are not only NOT stopping or even slowing the whaling and dolphin slaughter industries, they are implicitly 'demonizing' Japan, they tell us NOTHING about why the cetaceans need to be 'saved', and worst of all, they TOTALLY OMIT any reference whatsoever to the real global threats to cetaceans coming from human military-industrial activity. These paragons of 'environmental capitalistism' are true Orwellian 'liars'.(41)

One of the most salient dimensions of human dementia is our ability to justify or rationalize literally ANYTHING within the self-affirming system of our species mindset. We love to propound 'animal rights' and spend billions of $ per year to 'save' them, but at the same time we enthusiastically support the global meat industry, based on the enslavement and mass-murder of animals with souls, minds and feelings no less than any pet or 'wild animal'; an estimated 60 billion animals are slaughtered annually to satisfy the human craving for flesh.

A trend of late has been to ascribe to cetaceans the 'same rights as people' or 'person-hood' itself.(42) Think about what this really means. Any honest appraisal of how humans treat each other, especially the raging genocide that has characterized the relationship between 'civilized' modern man and indigenous peoples the world over, throughout what we call 'history', renders this totally absurd…or insane. How could

cetaceans possibly benefit from being 'officially recognized' as people? Would we then be obliged to show them…the same respect we have for each other?

In addition to being able to vote and be drafted and taxed, they could also hire solicitors to collect all the back-royalties and licensing fees for the astronomical quantity of audio recordings and still and motion-picture footage that has been 'taken' of them, without their permission; and to file numerous law-suits against tour operators, shipping companies, and the host of military-corporate entities waging war on them. They could file 'murder charges' against whalers, Japanese or not. They could launch petitions for their own protection on Facebook. They might successfully prosecute Paul Watson, Louis Psihoyos, and Greenpeace for fraud in raking in vast sums of money for pretending to 'save' them while not addressing the real issues. Surely were they to become 'people' this is what they would do!

In reading David Stannard's eye-opening and heart-shattering book American Holocaust I was stunned to learn that, according to his meticulous research of eye-witness accounts and official records, that well over 100 million indigenous Americans have been systematically slaughtered by European invaders to this day.(43) By some reckonings, over a billion human beings have been mass-murdered by fellow 'human beings' in modern times alone, not even counting the widespread active 'depopulation' programs of today. There's no way to know how many cetaceans have died at the hand of man, but we know without a doubt how many cetaceans have been killed by members of their own species: next to none. Cetaceans are not 'vegetarians', but, unlike 'civilized' man, not only do they do not kill each other, with a few exceptions, their observed behaviours tend to be extremely peaceful and non-violent.(44)

'People' or not, the fact that they continue to show deference to and tolerance of human beings in the face of our multifarious war on them, that they still show us 'friendship for no advantage', is a testament to their true level of spiritual evolution and proves that they are in fact light-years ahead of us in terms of what it really means to be 'human'.(45)

CETACEAN HOLOCAUST: THE REAL GLOBAL THREATS

We don't know for sure, but 'hunting' of animals for food by indigenous peoples seems to have been the norm for as far back as we can see. I'm not sure what the whales thought about being killed for food even back then, but Inuit in search of meat didn't have high-tech harpoon guns or whaling ships with sonar. Hunting was a sacred act to indigenous folk who took only what they thought they needed.

Although historically we believe we have 'always' eaten meat (what IF Neandertals were herbivorous?), 'civilized' man could easily abandon whaling and all other 'meat-driven' atrocities; yet these continue to run out of control as an integral part of our industrial 'doomsday machine'. Despite the publicity, of all the threats to cetaceans, whaling is at the bottom of the list.

Side-effects from the global fishing industry(46), another meat enterprise, have been a long-standing affliction for cetaceans, for example, drift- and gill-nets, in which hundreds of thousands of dolphins die from drowning and end up as 'by-catch' annually. Trawling in all its forms is also a widespread hazard for marine life in general.

Our pollution of the global ocean(47) is incomprehensible. Logically, the ocean is 'sea-level' located 'downhill' from everywhere on land: all water and everything in it running off from terrestrial sources ends up in the sea. Not only do all rivers empty into the ocean, 'civilized' man has been using the ocean as a sewer and waste disposal site for thousands of years. The ocean is huge, essentially 'terra nullius' (48) as far as most human cultures are concerned, and it's deep: substances or materials disposed of tend seem to dilute or just 'disappear'.

With the advent of shipping and motorized boats, for civilian, commercial and military purposes, noise(49), collisions(50), and contamination(51) from fuel, lubricants and wastes became wide-spread hazards as well. With the massive increase in all of these activities throughout the twentieth century and accelerating in the twenty-first, the global ocean is now saturated with a full spectrum of man-made noise that has raised the back-ground sound level by several dB.(52) The sea is also contaminated to varying degrees, ranging from huge 'dead zones'(53) where nothing can live, to areas that are relatively clean and undisrupted, with astronomical quantities of every industrial substance, compound, and chemical ever created, in particular, endocrine-disrupting POP's,(54) huge islands or 'gyres' of plastic,(55), and synthetic radio-nuclides from the real 'nuclear war' that has been going on since 1945.(56)

The global 'energy' industry is a major threat to all cetaceans. 'Civilized' humanity is addicted to the 'flesh and blood' of the 'body' of Mother Earth, and is stopping at nothing to consume every last ounce of minerals and petroleum that exists. Deep-sea mining and especially hydro-carbon exploration and extraction is growing exponentially in every part of the world. (57) Accidental leaks and 'spills' add insult to injury and enhance the toxic saturation levels.(58)

Seismic and electromagnetic geo-physical exploration technologies are extremely dangerous weapons in our war on cetacea. Hundreds of exploration vessels are in operation globally at any given time, each of which is equipped with an array of 'air-guns' that can emit under-water sonic explosions on the order of 30,000 joules per blast…enough to deafen or kill any cetaceans or other marine life within a radius of many kilometres.(59)

The frequency of accidents and disasters, as well as their damage-levels, have increased drastically in direct proportion to the scale and pervasiveness of industrial civilization as a whole. Solid evidence exists that in recent years a new paradigm of 'geo-terrorism' has been instituted which is a new form of covert warfare disguised as 'industrial accidents', 'natural disasters', and 'environmental engineering.'(60)

Recent examples of deliberate 'geo-terrorism' are the BP disaster in the Gulf of Mexico which began April 2010, and the Fukushima disaster which began in March 2011. Both these scenarios have clear 'signatures' of having been manufactured, and both are on-going processes, as opposed to events, which appear to have been strategically-premeditated acts of environmental warfare whose purpose is to poison the planetary biosphere via the ocean as efficiently as possible.(61)

As if traditional and/or 'conventional' warfare and weapons haven't been bad enough, for humans, cetaceans, and everyone else on Mothership Earth, today a 'new generation' of high-tech weapons systems has been deployed based on radio-frequency microwaves which allow 'secret wars' to be waged unknown to the affected populations. (62)

With the planetary metastasis of all-things-military since World War 2, going to the next level with the advent of the 'war on terror' since 9/11, and the presence of close to 4,000 U.S. bases and peripheral institutions around the world, the seas of Earth have become permanent 'theatres of operation', battle-fields, testing grounds, and waste-dumps particularly for the navies of the world. The U.S. Navy is the mac-daddy of all military entities on the planet, and is also THE single greatest threat to the well-

being of all cetaceans globally.(63)
Not only is the U.S. Navy the largest single military institution on Earth, it is also the single greatest 'nuclear entity', operating several hundred individual nuclear reactors for research, weapons, and propulsion of ships and submarines. They have overseen a large per-centage of all atmospheric atomic tests (including Project Argus, which permanently damaged the Van Allen radiation belts)(64), and have innumerable and classified 'super-fund' sites around the world, of which the global ocean is the biggest. They are more than likely 'legally allowed' to dispose of nuclear wastes from their reactors directly into the sea. Even if this weren't 'legal', who could stop them… or even find out?

The U.S. Navy has been the largest backer of research and development of the 'new generation' of microwave weapons since Reagan's 'Strategic Defense Initiative', or 'Star Wars' in the 1980's. These technologies, of which HAARP is one example, are huge antenna arrays with transmitters that target the ionosphere with giga-watt levels of heat. By means of super-computers and extensive research in geo-physical and atmospheric science, HAARP and other installations can function as an integrated weapons system which can conduct 'environmental modification', or 'weather warfare', 'tectonic' warfare involving man-made earth-quakes and vulcanism, and global 'mind control' operations which can neurologically debilitate entire human populations. Our biosphere in general is saturated with microwaves from other sources as well.(65)

Ironically, by means of unlimited funding, the U.S. Navy has also come to control almost ALL marine biology research on the planet, enabling them not only to 'weaponize' every dimension of the ocean and its inhabitants, but also to manage and control not only 'scientific information' but also to manipulate 'public perception' of what is really going on. Not only have they been engaged in enslaving, torturing and brain-washing cetaceans and other marine mammals for decades, to force them to function as 'robots', but their 'scientific research' has been shown to be deliberately and criminally fraudulent, in order to create the impression that nothing they do is harmful to anyone in any way. (66)

Of the full-spectrum of war on cetacea being conducted by the U.S. Navy, no form of attack or technology is more devastatingly and pervasively lethal as their mid- and low-frequency sonar systems. Sonar, which was inspired by cetaceans, and originally used only low levels of under-water sound to perform 'echo-location' for detection of 'foreign objects', has now been turned against them.

In July of 2000 I first learned of SURTASS, or LFAS, 'Surveillance Under-water Towed Array Sonar Systems' or 'Low Frequency Active Sonar.' These systems were being deployed on naval vessels around the world and were instantly recognized as major threats to cetaceans. Having been a lover of cetaceans for decades, this put me on full 'red-alert', as I knew that something horrific was up in the world. This was during that window of time when Bush 2 had been installed as president, which equalled 'war', but before 9/11, which came as no surprise to me after learning about LFAS.

These 'surveillance' systems use technology almost identical to that of seismic testing: huge under-water transducers that emit powerful explosions of sonic energy, which travel much faster and more intensely in water than in air. LFA-sonar is known to create 'a kill-zone the size of Texas'. These shock-waves of sound pressure energy literally explode the inner ears of cetaceans, cause hemorrhaging, rupturing of internal organs, and mass-death.(67)

Because of the extreme power-levels of seismic and LFA-sonar technologies, which are ostensibly about 'detection' or 'listening', it's become clear to me that these may be being used as active weapons systems. Against whom? Anyone who lives in the ocean.

In recent years innumerable and anomalous strandings of cetaceans, and 'die-offs' of many species of land and marine life-forms have occurred. These invariably correlate with the presence of military exercises and/or seismic testing activities. Tremendous effort goes into distancing the Navy and 'big oil' from any causality or accountability, as their legion of well-trained 'scientists' and compliant media distracts us with reports of 'mystery illnesses' and other fabrications.(68)

Almost no 'environmental organizations' dare to criticize or even mention 'big oil', for fear of financial retaliation; one wonders who in fact are the biggest donors to Paul Watson and Louis Psihoyos? Fewer still dare to criticize or mention the 'N' word, the U.S. Navy, as being anything more than 'stewards' of the global ocean.

Their greatest role as 'steward' of the ocean is their 'request' for a permit from the NMFS (National Marine Fisheries Service), a branch of NOAA, which they are known to 'own', to 'take' approximately 11.5 MILLION marine mammals over the next five years as part of their expanding war-games/testing/global presence strategy. 'Take' is Naval euphemism for 'kill'. Hats off to Rosalind Peterson for having the balls to tell the world about this true cetacean holocaust in progress.(69)

In summation, the cetaceans are under direct attack from human activity in a number of ways. These are physical (nets, collisions, whaling); psychological (being 'studied', held captive, experimented on); acoustic (noise, blasts, sonar); toxicity (chemical and radio-nuclear); and electromagnetic (HAARP and ATOC-related experiments/technologies)(70).

It's almost impossible fully to comprehend the damage that is being done to the global ocean and to the cetaceans who are the real 'stewards' of the sea. On top of all the on-going waste and chemical pollution pouring in for decades, massive quantities of atmospherically-disseminated chem-trail residues(71) are making their way into the sea. Scientists pretending to battle 'climate change' want to dump massive amounts of iron filings into the sea.(72) Crude petroleum continues to gush from the Macondo well in the Gulf of Mexico, and the Corexit continues to create illness in human and marine life.(73)

The 'icing on the cake' is the incomprehensible quantity of synthetic radio-nuclides pouring directly into the Pacific ocean from Fukushima, on top of what has already been deposited as fall-out from over 2000 atmospheric detonations, perhaps hundreds of thousands of drums of nuclear waste, and DU ('depleted uranium') deployed in all recent 'wars' and 'conflicts'. That a huge part of the global ocean could become one huge 'dead zone' is not impossible in our life-times; what is happening…what WE are doing…is beyond catastrophic for life as we know her, including the cetaceans. (74)

Individual cetaceans may be hunted or 'whaled' but whole populations are systemically endangered by the systemic poisoning of entire regions and the proliferation of new and dangerous technologies which can maim or kill tens of thousands of marine mammals with a single explosion.

Who is to blame for all this? WE are.

WE ARE THE PROBLEM

As a whole we are insane with respect to the 'reality' of global indigenous wisdom, ways of living and being in harmony with life and the Earth that have been around FAR longer than our highly destructive 'industrial civilization' which is turning the whole planet into a barren wasteland in the

blink of a cosmic eye.

It's possible that we are not our 'real selves' at this point in time. I really hope this isn't the 'real' us. If there is a 'real' us, I hope that it's much more like the cetaceans than what is generally passing for 'humanity' today. Whatever the reasons…the 'Kali yuga' (75) or 'permanent psychic mutation'…we have to realize that humans are the problem and humans can stop being the problem. Whatever the 'causes'…we are still responsible for what we, our entire species, is doing.

No 'them' exists who is responsible for what is happening; in terms of what's happening with the cetaceans, it's easy to point the finger at the Japanese, or at 'big oil' companies, or the U.S. Navy. These organizations consist of human beings, 'people'; ultimately, however, the problem is US. We in western society each make our daily contribution to our 'unconscious jihad against nature'. We each consume at least our share of resources, use our share of energy, produce our share of waste. Every time we pay a tax or even use money, we are supporting the military-industrial-banking complex; every time we get in our SUV's and burn some petroleum, we are supporting the VERY INSTITUTIONS who are the greatest threats to cetaceans. Driving more than any other 'consumer behaviour' truly supports the 'fascism-sponsored geo-terrorism' being conducted against the whales and dolphins.

Cetaceans don't use money or have possessions, they don't have territory, houses, clothes, or electricity; they don't need cars, radios, lights or books; theirs is a true spiritual non-material culture based on 'internal technology', supreme adaptation to their environment, constant mutual support, and tightly-knit social networks. We, on 'both hands', are trapped in 'language', often confusing the map with the territory; we are embedded in an increasingly artificial reality, a 'technosphere' that is toxic and unalive; we worship our self-proclaimed 'intelligence' and pronounce our 'dominion' over the kingdoms of life. We have little or no understanding of our own psychological processes, the nature of our 'dMOE'. We are ignorant of our own abilities and responsibilities.

All the problems that the Earth is experiencing, including the war on cetaceans, is a function of unenlightened human activity. The real limitations or barriers to communicating with or understanding the cetaceans as fellow sentient beings lie on the human side of the equation. We can't possibly understand 'anyone else' until we understand ourselves…we can't possibly 'ascend' into a 'higher dimension' while we're trashing this one.

My belief is that the cetaceans as a whole understand what is going on and are doing their best to be nice to us under extremely adverse circumstances, while we are waging war on them. They are encountering us with 'satyagraha' and the Golden Rule. (76) They are maintaining the highest possible spiritual wave-lengths in the face of mass-genocide.

WHO THEY REALLY ARE: THEIR MESSAGE...OUR LESSON

So far we've explored 'who' the cetaceans are from the perspective of mainstream science and popular culture, but we haven't really gone 'into their mind.' Maybe we haven't really been invited yet? We know that they are a lot like us, yet very different from us; we know that they must have a highly sophisticated 'internal reality' but we can't access it due to our lack of communication. We know that they matter just as much as do we.

Respect for cetaceans as fellow beings… true respect, not 'theoretical' or 'rhetorical' respect…as with anyone, is a necessary prerequisite for communication, but not only are we showing little 'respect' for them, we are waging war on them. IF they could suddenly 'speak' to us in English we might not like what we heard: "HEY! What's up with all the noise and killing? Why don't you all become vegetarians and learn to meditate and play flute?"

Our anthropocentric forms of communication, particularly the 'double-edged sword' of symbolic language, may have served us all too well in our games of 'progress', but to all other life-forms on Mothership Earth, our constant blatherings and transmissions must be little more than an irritating noise, lacking the melody and harmony of bird- or whale-song or the intricate beauty of cricket chirps; this is how most human use of language sounds to me! Our actions speak far louder than our words when it comes to how 'mitakuyse oyasin' perceives human beings. In the larger reality, the context of life on Earth, humanity is both obsessed with its own artificial reality and doing its best to make natural life a thing of the past. "Western man's ethic is not directed toward the preservation of the earth that fathered him." (77)

Although we can only 'know' the cetaceans through the lenses and filters of our own dysfunctional 'dMOE', our own psychology, another mode or channel of non-sensory 'communication' seems to exist, that of telepathy. We don't really know what it is or how it works, but it is definitely a real phenomenon. A large number of people who have spent time with cetaceans and know them well remark on how telepathic they seem to be. The exact nature of the experience is elusive, but when it's happening you know it's real. (78)

I think that the cetaceans are using their highly advanced 'internal technologies' of group-telepathy and holographic consciousness-transmission to beam their love and message into the human psyche, now more than ever. Since they've been here at least ten times longer than we have, this could be a long-standing connection that humans-in-their-present-state have forgotten. This could also be a survival imperative on their part.

The exciting part is that telepathic thought transfer may be only the tip of a huge ice-berg of advanced mental abilities the cetaceans have, ones that we, too, had but in general have atrophied from lack of use and/or been drowned out by the info-toxic and electromagnetic cacophony of 'civilized' life. (79)

Being able to experience their 'reality' could be humbling as well as mind-blowing to 'man, the wise.' Some of us are able to connect with them telepathically and spiritually, a sphere of connection that's existed since before us, but as a whole, we live in a vacuum of inter-species understanding. In general, we seem to be content with our commonly-held misconceptions. When we consider 'communication', we tend to think in terms of 'translating their "language"' or 'decoding their transmissions' but in reality their primary 'message' to us may be far less complex than sophisticated multi-dimensional stereo-holographic 'pictures' or sequences of clicks and whistles. (80)

Without making a sound or beaming us telepathically, the most fundamental message the cetaceans have for us is shared purely by the example they set: "live simply so that others may simply live."

For now the inner life of cetaceans remains a complete mystery. Living in the ocean before human industrial civilization, they would have enjoyed the immense peace and tranquility of a non-electric environment, mingled with the music of their various sounds, playing, living in close-knit family groups, in constant motion, travelling oceanic 'song-lines' and tuning into what was happening with Mother Earth and the universe. For all we know, cetaceans in general might be the equivalent of human yogis, spiritual masters, artists, musicians, dancers, martial arts experts, philosophers

and poets…or beyond. They might have a highly-evolved 'group mind', a 'group-synaesthesia' akin to a real-time shared psychic multi-dimensional 'broad-band internet'. They might have their own equivalents of our astronomy, and be in touch with life in other star-systems. And certainly they don't bear the psychic scars of having mass-murdered each other for thousands of years.

In the oceans of today they are under such violent attack that their 'normal' lives would seem almost impossible to maintain. How they are able to live under these circumstances and still be nice to us is even more of a mystery than 'who' they really are.

The most powerful encounter I have had with cetaceans was two years ago when my partner Liesbet and I were swimming in the ocean off of Great Barrier Island, New Zealand. We were in waist-deep water frolicking around when all of a sudden three dolphins appeared. We were thrilled as they came to within about a meter of us. They seemed to be 'beaming' us with some kind of 'energy' that we could definitely feel; they went away then returned and did the same thing again. After a while they left, but Liesbet and I were forever changed by this 'close encounter' with a true 'extra-terrestrial intelligence.' We came away with a feeling not only of being 'healed' or having our health 'boosted' in unknown ways, but, more significantly, we felt that the dolphins imparted an immense sense of urgency to us. A warning, perhaps, of something dangerous looming on the horizon. This impression never left us, and when the Christchurch quakes and Fukushima nuclear disaster happened a few months later, it all began to make sense: they knew what was coming…because they've seen it happen before?

Within their collective psyche they may have memories and knowledge of the history of Earth and humanity that we are unable and/or unwilling to access. They may have knowledge of life elsewhere in the universe…of telepathically-connected galactic communities…and a greater appreciation of the beauty and uniqueness of life on THIS planet. Perhaps the are the 'mind of Gaia' herself. (81)

If we are somehow able to stop waging war on the 'ultimate indigenous people', and find ways to listen to and act on their 'message' to us, then the door could open for an inter-species 'psychic symbiosis' that might have existed before but could certainly happen again. If and when this happens, everything we think of as 'reality' could change dramatically; it might be like waking up after an extended night-mare.

PASSENGERS/CREW OF MOTHERSHIP EARTH

Humans and cetaceans, along with every other form of life, are the passengers and crew of Mothership Earth. She is the only planet we know of who has life. The gravity of the current scenario that is playing out on Earth is truly incomprehensible to the mind of homo sapiens: how can we get our heads around the fact that it is WE who are doing our best to destroy all life on the only planet we know of who has life?

We cannot be sure what the cetaceans 'think' about this, but I believe that we are receiving a vast amount of truly spiritual love and vast psychic guidance from our fellow 'co-conspirators' in the web of life.(82) They might have far greater understanding of and insight into what is 'really' going on with humanity and the Earth; with a consciously and creatively re-programmed dMOE humans as a whole could not only come to share this expanded world-view, but would of necessity re-navigate our overall process away from oblivion and towards the honouring, respect and nurturing of all life. This is the work we must dedicate ourselves to.

The cetaceans have been here all along, waiting for us to wake up and snap out of our brutal night-mare that's been going on for thousands of years.

How do we 'save the whales'? By being aware of how each of us contributes to the war on life that 'civilization' is fundamentally based on, and acting to modify these unquestioned behaviours. A radical reduction in driving, in consuming hydrocarbon fuels would be a great move, as well as radical reduction or complete elimination of meat in our diets. Awareness is the key, owning it and keeping it in the forefront of our minds and hearts. If we really care about life and change our lives in ways that show it, we will begin to reduce the extremely negative collective karma we have accrued, a spiritual force that is driving our self-destruction.

If we live by the example of the cetaceans: satyagraha, the Golden Rule, 'friendship for no advantage, 'live simply so that others may simply live'…if we make these real in our day-to-day lives, there's no need to donate money to non-profit organizations.

If we realize that each of us has enormous abilities and talents, a vast inner life, we may find the inspiration to become more cetacean-like ourselves, and therefore find our true selves, our true nature as 'people', as human beings.

I will close with what could be the ultimate 'science-fiction' scenario…because it looks like it's really happening. Dr. John C. Lilly, with whose dolphin communication group I was involved in the early 1980's, speculated that the whales and dolphins acted as 'repeater stations' for signals from water-based life-forms or 'Gaian intelligences' in other star systems, and that this was one of their primary functions here, to maintain this ancient and essential connection. I personally have felt a powerful link between the whales and dolphins, what I refer to as the 'spirit of life', and the art and consciousness of the Australian aborigines, who are THE oldest human culture with the most long-standing relationship to Mother Earth. (83) Lilly's perception or vision was that humanity was being influenced below our level of awareness by energies or transmissions from another form of 'intelligence' in other star-systems, a solid-state 'life' based not on water, carbon and DNA, but on silicon and electricity. This SSE, or 'solid state entity' has been influencing humanity to design and construct an entire 'civilization' running on electricity and computers whose ultimate purpose is first to replace then to eliminate entirely water-based life-as-we-currently-know-her, including ourselves. The cetaceans are specifically targeted as being the most powerful receivers of the 'signals' from water-based life.(84) When I look around at what is happening in the world today, the extreme proliferation of all-things-electronic, the dangers of EMR, micro-waves, and the 'new generation of Tesla-based weapons technologies, the mutagenicity of electricity and the centrality of computers for the existence of the entire planetary mega-machine and war apparatus, it really looks like this is coming true.

Is THIS world we are creating a world that we REALLY want? Time is short. Time to wake up.

"Live simply so that others may simply live."

For a brief survey of my involvement with cetaceans:
http://synthaissance.blogspot.com.au/2008/06/notes-on-my-connection-with-arthur-c.html

Trailer for the 'beyond film' about cetaceans that my partner Liesbet Verstraeten and I are working on: http://youtu.be/eNFoL24pK3c

FULL ARTICLE AND FOOTNOTES HERE:

http://tutunui-wananga.blogspot.com.au/

Dear + Michael Payne

As you are aware, starting November 1st, which happens to be my Birthday, the seismic tests will begin along the Central Coast, involving 260 decibel sound blasts by Pacific Gas & Electric who own the Diablo Canyon Nuclear Power Plant nearby. The blasts will come every 13 seconds 24 hours a day seven days a week for about 1 month. The blasts are expected to kill all whales in the area, and threaten other sea life, such as dolphins, who are very sensitive in hearing!

As you are also aware by this point, extreme amounts of whales have come to our portion of the coast, especially near Avila and the very heart of the area where the testing will begin. Whether a sign or not, they are a wonderful reminder of our oceans glory and how much we should be protecting these environments, not creating more instability in them.

The whales and other creatures are an asset to the sea and to our communities.

Do not be afraid to do the right thing and say no to the testing. We should be on the path to peaceful existence not creating more harm. The Diablo Canyon Nuclear Plant is a bowl full of wrong right now, with safety measures and aging equipment, and the last thing it seems to need is some ground pounding to possibly activate a fault line (which runs right through it).

Lets together preserve our oceans and our quality of life. The

RECEIVED
09-26-12
PRI

people of the area do not want the testing. The whales do not want the testing. Why is only a big corporation the one being listened to? Hardly seems fair, or the basis of the America I believe in.

And really it would be the best Birthday Present ever.

Feel free to call me anytime concerning this potentially horrific situation. I may not be the most knowledgable person on the subject, but I come from the heart, and I know that stopping the seismic testing would be the right thing to do. A step for our surroundings and fellow creatures since they cannot write the letters or speak our language. We are smart enough to speak theirs. We know collectively that the things we are doing are not helping them.

Together let's change that.

Sincerely,

Jennifer Randall
San Luis Obispo, Ca.

(620) 899 4060

jenrandallart@yahoo.com

ITP Goldstein <itp.goldstein@noaa.gov>

No Seismic testing

Jill Finch <jillefinch@gmail.com> Wed, Oct 10, 2012 at 4:49 PM
To: ITP.Goldstein@noaa.gov

I am writing to voice my request that you deny PG&E plans to perform extreme levels of Seismic testing off the Coast of Central California. We already know there's an earthquake fault there, very close to the aging Diablo Nuclear plant. The little bit of new information that may possibly be obtained is not worth the potential costs. Most concerning is the cost in damage to the ecosystem that very probably will result from such high & extended decibel blasts. We live here because we love & respect the Ocean & all of the beauty & life it holds. And very many of us depend on the economies that it supports.

Please realize that the potential destruction & negative impacts far out way any minimal information that may be obtained. Do not support PG&E's Seismic testing off Point Buchon.

Thank you,
Jill Finch
Cayucos, CA

ITP Goldstein <itp.goldstein@noaa.gov>

a Story

joanna spinoza <jrspinoza@yahoo.com> Wed, Sep 19, 2012 at 3:26 PM
To: ITP.Goldstein@noaa.gov

The following is a very short story of how I feel about the issue on the table right now. Thank you for reading.

Local Inhabitants and World Travelers

Who do you know who has lived along the beach, or who has traveled the world? Who do you know that lives surrounded by friends, neighbors, and family? Who do you know that provides food for others? Who do you know who has ever traveled on a highway, or been to a harbor, or swam and played in the ocean ? Have you?

Yes? Then please consider this:
All the Inhabitants and All the World Travelers in a Huge Area very near to where we live, here in California, may soon be suddenly Killed or Seriously Injured by a very large (Evil) corporation ! This is the Plan! Really!
The Local Inhabitants in that area will have NO Idea that this is going to happen, nor is there any way for them to Escape from this. It is planned to happen very soon.
The World Travelers coming into this area will also be Killed, along with their Babies and Juveniles. They will have NO chance to escape this Fate.
NOT a Single One will survive. ALL Life will be Destroyed.
Every One will perish, and NO One will be able to help them. NO ambulances, NO paramedics, NO doctors, and NO hospitals will be able to Save them. They will just be doing their normal activities, cruising along, having dinner, playing in the water, or traveling through.
Then the Attack.
And NOT just one Attack, but a constant Onslaught of Deadly Bombs going off ~ for MORE than a month! ~ until Every Single One is dead!

Can you even Imagine what that would be like?
What if you had many Friends who lived there? or Family?
How would that make YOU Feel?
Wouldn't you want to STOP this large corporation from doing this Evil thing?
I know I would.
But HOW?
First, I would find out who that corporation is.
And Then I would do Everything possible to STOP this from happening.
I would ask All my Friends to Help, and also ask Every One in the World too.
And I would do this Right NOW.

WE CAN DO THIS. But the Ones who Live where this is planned have NO idea about this, They have NO Voice, and They have NO Way to Take Action. So, it is up to US ~ Humans ~ to STOP this from happening!

WE MUST STOP the corporation ~ PGE ~ Pacific Gas and Electric ~ from their Evil Plan to Blast sonic Bombs under the ocean water, in the California State Marine Reserve near their Diablo Canyon Nuclear Power Station.
This is Our Pacific Ocean! NOT Theirs!
This Evil action would KILL All the whales AND their Babies who Travel these waters. It would KILL All the Sharks and Dolphins! KILL All the Turtles, the Seals, the Otters, the Sea Stars, the Sea Urchins, ALL the FISH ! ~ EVERY Living Being in the area of the Pacific Ocean near our coast here in San Luis Obispo. This would keep You and Me and Everyone from going in the water while this is happening. It would Take Away the Fish from the fishermen and from Us!
NO, THIS MUST NOT HAPPEN !

We MUST be OUTRAGED that this can even be considered!
We MUST STOP the Seismic Testing by PGE ~ BEFORE they start!
Our Ocean Friends MUST be Saved !

Thank you for reading. As you can see I am outraged at this contemptible plan. A plan that is totally destructive and unnecessary as there are other ways to determine what lies below the surface of the water and the sea bed.
PLEASE ~ do not allow this plan by PGE to be implemented.
Sincerely, joanna Spinoza
Cayucos, California 93430

ITP Goldstein <itp.goldstein@noaa.gov>

(no subject)

João Miguez <joaoshakia@gmail.com> Sun, Oct 14, 2012 at 6:49 PM
To: ITP.Goldstein@noaa.gov

Dont make this please!!!! dont kill the mammals marine!!!
I from Brasil, My inglech is not good, but... i think you understand!
Please, dont make this.

--
João Miguez
48 - 99688892
www.joaomiguez.blogspot.com

ITP Goldstein <itp.goldstein@noaa.gov>

Opposed to PG&E Seismic Testing off Central California

John Kenny <jkcckf@gmail.com> Thu, Oct 4, 2012 at 8:27 PM
To: ITP.Goldstein@noaa.gov

P. Michael Payne
Chief, Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

Hi - My name is John Kenny. I am the founder of Central Coast Kayak Fishing and I strongly oppose the proposed seismic testing by PG&E.

This area is part of the Central Coast MLPA protected areas. Under no circumstance should PG&E be allowed to perform these tests.
Have these types of tests been conducted in other ocean waters which are less sensitive? If not, why would anyone allow them to harm the delicate ecosystem here?

We as recreational fisherman in my club have respected the enactment of the MLPA. I realize there have been strong objections to their implementation but we in CCKF have respected the zones since their inception. Sending a sound pressure wave of 250 decibels will be extremely devastating to the marine life in the area. Sound pressure levels amplify under water. If nobody from PG&E or the scientific community can say exactly what the effects will be, and specifically the effect on each species, then this simply cannot be allowed.

I also own a music store and have 25+ years experience as a sound engineer. Let me give you this analogy. Imagine going to the loudest concert possible. 120 decibels would make you cringe to a point where you would want to leave. Now double that sound level, amplify it, and place yourself right next to the speakers at the stage. You would be deaf instantly … for life. No question about it.

Now imagine if you were a 16" Cabezon.

We both know fish use their lateral lines for orienting themselves, finding prey, and schooling with other like fish. Fish use their swim bladders to control depth and buoyancy as well as to produce or more importantly in this case, RECEIVE sound. I would not be surprised if the pressure alone from 250 decibels would rupture many species swim bladders near where the test is set to occur. Fish far off in the distance would feel this through their lateral lines and swim bladders and sent careening in a mass panic. 250 decibels would certainly rupture your ear drums…. imagine what it will do to the marine life.

Nobody has the answers to the effects of these tests. You don't, and PG&E doesn't know either. Anticipated effects are not good enough. This is not the area to wing it and *see what happens*. PG&E cannot be permitted to move forward with this testing.

Respectfully submitted,

John Kenny
Founder Central Coast Kayak Fishing
Founder and Owner Faultline Music Paso Robles, CA

Judith L. Griffin

1327 Tanglewood Drive

San Luis Obispo, CA. 9340

805-543-2310

P. Michael Payne, Chief,
Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries
Service, 1315 East-West Highway, Silver Spring, MD 20910.

Dear Sir;

The harassment of Marine Manuals is not ok, and the displacement of thousands of animals, millions of fish and the destruction of millions of larvae and plankton will create the largest environmental and economic disaster that has ever hit this state. The harassment of Western Gray Whales, Eastern Gray Whales, Northern Elephant Seals, porpoises and Sea Otters will be devastating to the stock. I am asking you to **DENY** the IHA and not allow this mass damage to our precious ocean. We have a chance as humans to step up and protect our precious Marine friends and I hope we can pull together and rise to the task by doing the right thing.

Thanking you in advance for your consideration,

Judith L. Griffin

Judith L. Griffin

October 4, 2012

RECEIVED
10-10-12
AR1

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Call off Seismic Testing

Howard Goldstein <howard.goldstein@noaa.gov> Tue, Oct 16, 2012 at 9:32 AM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Julia Ransom** <juliaransom17@gmail.com>
Date: Tue, Oct 16, 2012 at 9:29 AM
Subject: Call off Seismic Testing
To: Howard.Goldstein@noaa.gov

Dear Mr. Goldstein,

Concerning PG&E's Diablo Canyon Nuclear Plant:

As you know, the baselines are shifted, the whales are endangered already, seismic testing does nothing to improve our safety, and the Harbor Porpoises and Otters could be rendered completely extinct if this unnecessary seismic testing is allowed to go forward.

I site this article: http://www.scientificamerican.com/article.cfm?id=nrc-report-says-diablo-canyon-able

I am begging you to call off all seismic testing. The oceans don't belong to you or to me but to the world and to the living beings that inhabit them. Please, do the right thing.

Sincerely,

Julia Ransom

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

NOAA FISHERIES

Subscribe and get the Scientific American iPad App (NEW!)
Subscribe

NRC Says Diablo Canyon Nuclear Station Can Withstand Shoreline Fault

The Nuclear Regulatory Commission said its latest analysis of seismic faults near PG&E Corp's Diablo Canyon nuclear station in California showed the coastal plant could withstand an earthquake generated by an offshore fault identified in 2008, according to a statement on Friday.

REUTERS

HOUSTON (Reuters) - The Nuclear Regulatory Commission said its latest analysis of seismic faults near PG&E Corp's Diablo Canyon nuclear station in California showed the coastal plant could withstand an earthquake generated by an offshore fault identified in 2008, according to a statement on Friday.

The NRC's report focuses on the latest identified earthquake source, called the "Shoreline fault," just offshore from the plant in San Luis Obispo County, about 183 miles northwest of Los Angeles.

Diablo Canyon operator Pacific Gas & Electric said it welcomed the NRC finding "which confirms that Diablo Canyon is seismically safe and is designed to withstand the maximum ground motions that seismic faults in the region are believed capable of producing," in a separate statement.

PG&E notified the NRC about the Shoreline fault in 2008. At 2,240 megawatts, Diablo Canyon is the larger of the state's two nuclear power plants, supplying about 10 percent of the state's power needs.

"Both PG&E and the NRC are continuing to look at the seismic characteristics of the Shoreline fault," said NRC spokesman Victor Dricks. "This research information letter

SCIENTIFIC AMERICAN | FSG Books

The Best Science Writing Online 2012

Showcasing more than fifty of the most provocative, original, and significant online essays from 2011, The Best Science Writing Online 2012 will change the way...

Read More »

Scientific American Products

Scientific American Digital

Browse 200+ Issues
View the Latest Issues
View Anytime, Anywhere

Subscribe

More to Explore

It's Not Just Fukushima: Mass Disaster Evacuations Challenge Planners

Will Future Nuclear Power Reactors Be Safer?

Many U.S. Nuclear Plants Ill-Prepared to Handle Simultaneous Threats

China Syndrome: Going Nuclear to Cut Down on Coal Burning

Nuclear Mishap or Meltdown?: It's All a Matter of Degree

Latest News | Most Read

QUICK AND DIRTY TIPS | 2 hours ago
How to Use Math to Send Encrypted Messages

SCIENTIFIC AMERICAN MAGAZINE | 2 hours ago | 1
Does Congress Get a Passing Grade on Science?

represents the staff's latest analysis and basically concludes that the plant, as designed, would withstand any earthquake the Shoreline fault would generate."

An NRC team visited the site in 2011, the agency said. Analysis from the visit and available information indicates that ground motion from earthquakes the Shoreline fault could potentially generate would fall within Diablo Canyon's existing design limits, the agency said in its report.

The plant's design limits are based on ground motion associated with an earthquake from the larger Hosgri fault near the plant, the NRC said.

Separately, PG&E is performing a $64 million seismic research effort mandated by the state legislature using three-dimensional seismic tests to better understand the hazards posed by potential earthquakes near the plant.

In August, the California State Lands Commission voted to allow the utility to move forward with the advanced tests using powerful sonar devices despite concerns about the impact on marine life.

At the request of the utility, its NRC application to extend the two Diablo Canyon reactors' operating licenses beyond 2024 and 2025 will not be finalized until the advanced seismic research called for by the state is completed.

For the NRC, Diablo Canyon must perform additional earthquake evaluations, as well as a "walkdown" to identify any near-term actions for enhancing earthquake resistance as part of the agency's ongoing response to the 2011 Fukushima Daiichi nuclear accident in Japan which was triggered by an earthquake and tsunami.

"As part of our strong commitment to safety, PG&E has and will continue to study the seismicity of the region to give us, our regulators and the public confidence that the plant remains safe," the utility said.

(Reporting by Eileen O'Grady in Houston; Editing by Bernard Orr, Gary Hill)

REUTERS

Reprints and Permissions »

Like 9 Tweet 0 1 Share reddit this!

4 Comments

Add Comment

1. DancerTiffy
10:34 PM 10/14/12

So---the nuke plant was built on an area prone to earthquakes but it's going to be ok anyway and not to worry?
I don't think so.

Reply | Report Abuse | Link to this

2. dwbd
in reply to DancerTiffy
11:57 PM 10/14/12

Don't worry me and I would say I know one whole lot more than you about the risks of that Nuclear Power plant. Quite happily live right within the plant boundary - no problem. Next door to a Coal power plant, Oil Refinery or Natural Gas generator - I'll pass on that.

ANTHROPOLOGY IN PRACTICE | 5 hours ago
The Story of Grand Central Station and the Taming of the Crowd

PLUGGED IN | 9 hours ago
Has energy production increased or decreased on federal lands?

DOING GOOD SCIENCE | 11 hours ago
On the apparent horrors of requiring high school students to take chemistry.

Follow Us:

See what we're tweeting about
Scientific American Editors

katewong Sullivan: maybe coexistence of giant carnivores not so rare after all. #2012SVP
1 hour ago · reply · retweet · favorite

katewong Corwin Sullivan now talking about Chinese tyrannosaurids. 2 giant species coexisted in Zhucheng ecosystem. #2012SVP
1 hour ago · reply · retweet · favorite

marisfessenden .@sciam grades Romney's and Obama's responses to science policy questions: http://t.co/QbBROqlN I go after Congress: http://t.co/Hzp3zcCb
1 hour ago · reply · retweet · favorite

More »

Free Newsletters
Get the best from Scientific American in your inbox

Email address

Latest from SA Blog Network

To live and work at CERN
Guest Blog | 1 hour ago

The Story of Grand Central Station and the Taming of the Crowd
Anthropology in Practice | 5 hours ago

ISS Startrails Video
PsiVid | 8 hours ago

Has energy production increased or decreased on federal lands?
Plugged In | 9 hours ago

#SciAmBlogs Tuesday - athletic ape, singing

Reply | Report Abuse | Link to this

3. quantumxdt
09:40 AM 10/15/12

WELL THERE YA GO!
Reminds me of the federal park, (Meager Creek, British Columbia), I went to from time to time; enjoying the hot springs there only to find one year in the infinite wisdom of the engineers who installed the septic system placing the outhouse directly in the fall-line of the hill above the hot springs ...cracked and leeched causing a health hazard ...closing the hot springs and all it's rustic beauty.

The springs were free to enjoy built by loggers years and years before; the Federals in their infinite wisdom removed all the debris, (logs supporting the hot spring pools and all the rocks with years of candle wax around the pools (3 in total)); believe me it was a sight to behold,(after the kids went to bed!), in the night with a hippy type attendance, candles, and drinks for all my friends; Most of those around were society members of the world renowned beach,(Wreck Beach), at U.B.C. Vancouver. The place was starting to get a lot of recognition outside the regular crowd. The local Tribe as the unofficial stewards brought home the beauty and pull of the earth with their attention to the area. Some telling me the local lore or to any who listened; However, it was all for naught for progress had come.

The Federals again though up an excellent solution....cement the bottoms & sides complete with drain holes and plumbing after the cleanup and charge a fee for use ...smart huh!

There is an excellent story beyond this short excerpt but after all it's another story.

I am saddened that greed has hidden the truth of what the simple power H2O has and how we all can have it for free just like that hot spring story above but alas that's another story too.

Reply | Report Abuse | Link to this

4. littleshell
10:26 AM 10/15/12

If the NRC says the Diablo Canyon Nuclear Waste Plant is safe, then they must call off the seismic testing scheduled for November using 260db air canon blasts every 13 seconds that will destroy most marine life and all our newly minted Marine Reserves and Sanctuaries. Of course, scientific Americans might want to examine the work of seismologist Jim Brune.

On facebook: Stop the Diablo Canyon Seismic Testing

Reply | Report Abuse | Link to this

Add a Comment

You must sign in or register as a ScientificAmerican.com member to submit a comment. Click one of the buttons below to register using an existing Social Account.

fish, teaching chemistry, Ada Lovelace, diatoms, oxytocin, and more.
STAFF The Network Central | 9 hours ago

News From Our Partners

REUTERS
UK shale gas not at odds with climate targets: report

nature
Politics holds back animal engineers

FAST COMPANY
An Infographic Breakdown Of The World's Greenest Cities

techmedia
Carbon Dioxide Might Damage Glaciers

ClimateWire
Maine Restores Undersea Plants to Protect Economy

AccuWeather.com
Earth's Strongest, Most Massive Storm Ever

cnet
iPad Mini, anyone? Apple sets Oct. 23 event

Science Jobs of the Week

Post-Doctoral Researcher; Programme: Bioinformatics and Genomics; Group: Gene Function and Evolution
CRG - Center for Genomic Regulation

Postdoctoral Associate
University of Minnesota

Professor in Translational Medicine and Director of Research Programs Unit
Faculty of Medicine, University of Helsinki

More jobs from Naturejobs.com »

Ads by Google

Mitt Romney-Official Site
Romney Will Repeal Obamacare as Quickly as Possible. Donate $5 now
www.MittRomney.com

Walden University Online
Find the Degree to Help You Get the Career You Want. Apply Now!
Waldenu.edu

FreeCreditScore.com™
A Good Credit Score = 700 & Above. See Yours Now for $0.
www.FreeCreditScore.com

If You're 50+ Read This
Here's A Quick Way To Help Your Joints Feel Better! See What To Do
www.Instaflex.com

SCIENTIFIC AMERICAN nature jobs

TRY A RISK-FREE ISSUE

YES! Send me a free issue of Scientific American with no obligation to continue the subscription. If I like it, I will be billed for the one-year subscription.

Email Address

Name

Continue

Scientific American is a trademark of Scientific American, Inc., used with permission

© 2012 Scientific American, a Division of Nature America, Inc.

All Rights Reserved.

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Mail delivery failed: returning message to sender

julie greco <gardenkeeperjg@earthlink.net> Sun, Oct 14, 2012 at 8:56 PM
To: ITP.Goldstein@noaa.gov

Begin forwarded message:

From: Mail Delivery System <Mailer-Daemon@elasmtp-mealy.atl.sa.earthlink.net>
Date: October 14, 2012 8:52:44 PM EDT
To: gardenkeeperjg@earthlink.net
Subject: Mail delivery failed: returning message to sender

This message was created automatically by mail delivery software.

A message that you sent could not be delivered to one or more of its
recipients. This is a permanent error. The following address(es) failed:

goldstein@noaa.gov
SMTP error from remote mail server after RCPT TO:<goldstein@noaa.gov>:
host noaa.gov.s9a1.psmtp.com [74.125.148.10]:
550 No such user - psmtp

------ This is a copy of the message, including all the headers. ------

Return-path: <gardenkeeperjg@earthlink.net>
Received: from [69.120.250.143] (helo=[192.168.1.101])
by elasmtp-mealy.atl.sa.earthlink.net with esmtpsa (TLSv1:AES128-SHA:128)
(Exim 4.67)
(envelope-from <gardenkeeperjg@earthlink.net>)
id 1TNYvD-0007ZY-ST
for goldstein@noaa.gov; Sun, 14 Oct 2012 20:52:43 -0400
From: julie greco <gardenkeeperjg@earthlink.net>
Content-Type: text/plain; charset=us-ascii
Content-Transfer-Encoding: quoted-printable
Subject: navy nonsense
Date: Sun, 14 Oct 2012 20:52:42 -0400
Message-Id: <8120378E-9381-4450-A7E1-4655E71FC8E9@earthlink.net>
To: goldstein@noaa.gov
Mime-Version: 1.0 (Apple Message framework v1085)
X-Mailer: Apple Mail (2.1085)

What the hell are you people thinking even considering this? Leave the =
marine mammals alone and stop looking for ways to harm and KILL them. =
This thinking is environmentally disastrous and lacks conscience! Julie =
Greco=

ITP Goldstein <itp.goldstein@noaa.gov>

Diablo Canyon Seismic Testing

julharper@earthlink.net <julharper@earthlink.net> Fri, Oct 5, 2012 at 1:01 PM
To: ITP.Goldstein@noaa.gov

Dear Sir, I am writing to protest the seismic testing for PG$E. This power plant was built near active earthquake faults when the dangers of nuclear power were not well known. It should not be there, and our ocean ecosystem should not have to suffer because PG$E wants to stay open. It is wrong to destroy our sacred wildlife for this purpose. The often crude motives of economics must stand down to the delicate balance of our ecosystem, and the ocean life which is so crucial to it. I am told that there are other means of gathering more information about these earthquake faults, and those should be used, if any. It is my opinion that that plant is unsafe no matter what, due to it's location, and this is all just a tragic show. It is now well known that, because of the movement of those tectonic plates, Diablo is in a precarious position. Please act intelligently in a situation rife with grave consequences. Thank you so much for your time. Best regards, Julie Harper 15 Essex St., #1/Dover, NH 03820 (SLO native)

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: stop seismic testing for Diablo Canyon

Howard Goldstein <howard.goldstein@noaa.gov> Tue, Oct 16, 2012 at 9:06 AM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: <julharper@earthlink.net>
Date: Mon, Oct 15, 2012 at 11:56 PM
Subject: stop seismic testing for Diablo Canyon
To: Howard.Goldstein@noaa.gov

Dear Mr. Goldstein, I am writing to respectfully ask that you do everything in your power to stop the seismic testing in the waters off of Diablo Canyon Nuclear Power Plant. The National Marine Fisheries Service is supposed to protect our marine mammals through the Marine Mammal Protection Act of 1972. The baselines are shifted, the whales are endangered already, seismic testing does nothing to improve our safety, and the Harbor Porpoises and Otters could be rendered completely extinct if this unnecessary seismic testing is allowed to go forward. Thank you very much for your time and efforts!! Best regards, Julie Harper

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

ITP Goldstein <itp.goldstein@noaa.gov>

Objections to the Issuance of an Incidental Harassment Authorization/Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California

Julie Tacker <julietacker@charter.net> Mon, Oct 15, 2012 at 4:10 PM
To: ITP.Goldstein@noaa.gov

Feel free to contact me with any questions you may have.

Julie Tacker
PO Box 6070
Los Osos, CA 93412
805-528-3569

3 attachments

NOAA_NMFS_Comments.pdf
445K

NRC report on Shoreline.pdf
357K

Seismic_Take By Harassment_cumulative.pdf
284K

“Take By Harassment” Cumulative Impacts to Marine Mammals

Individuals in 160 dB “Safety Radius” Requested Take Authorization (with additional 25% for repeated exposure)

	Central Coastal California	So. California Collaborative Geophysical	
Common Name	**Requested Take Authorization**	**Requested Take Authorization**	**Totals**
Mysticeti			
California Gray Whale	97	357	454
Fin Whale	20	14	34
Humpback	13	3	16
Blue Whale	15	33	48
Minke Whale	1	2	3
Sei Whale	0	1	1
Odontoceti			
Mesolodont beaked whale	6	0	6
Short-beaked common dolphin	1,834	10,036	11,870
Long-beaked common dolphin	82	385	467
Small beaked whale	8	13	21
Phocoena phocoena			
Morro Bay Inshore Stock (<92m)	4,386	0	4,386
Morro Bay Offshore Stock (>92)	284	0	284
Dall’s porpoise	81	14	95
Pacific white-sided dolphin	189	269	458
Risso’s dolphin	98	178	276
Northern right whale dolphin	114	38	152
Striped dolphin	8	4	12
Baird’s beaked whale	3	0	3
Bottlenose dolphin			
Coastal (year round)	1,652	2,526	4,178
Offshore (summer)	1	40	41
Offshore (winter)	2	478	480
Sperm whale	2	1	3
Dwarf sperm whale	5	0	5
Short-finned pilot whale	1	2	3
Killer whale (Orca)	11	7	18
Pinnipedia			
California sea lion	1,062	6,085	7,147
Northern elephant seal	0	175	175
Pacific harbor seal	76	0	76
Guadalupe fur seal	0	49	49
Fissipedia			
Southern sea otter	1,485	0	1,485
Prepared by J. Tacker, 10/7/12	**11,536**	**20,710**	**32,246**

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 12, 2012

Mr. Edward D. Halpin
Senior Vice President and
Chief Nuclear Officer
Pacific Gas and Electric Company
Diablo Canyon Power Plant
P.O. Box 56, Mail Code 104/6
Avila Beach, CA 93424

SUBJECT: DIABLO CANYON POWER PLANT, UNIT NOS. 1 AND 2 – NRC REVIEW OF SHORELINE FAULT (TAC NOS. ME5306 AND ME5307)

Dear Mr. Halpin:

On January 7, 2011, Pacific Gas and Electric (PG&E, the licensee) provided the U.S. Nuclear Regulatory Commission (NRC) with a report on the analysis of the Shoreline fault. This report can be found in Agencywide Documents Access and Management System (ADAMS) Accession No. ML110140431. This report provided new geological, geophysical, and seismological data to assess the potential seismic hazard of the Shoreline fault.

Based on our review, the NRC has confirmed our preliminary conclusion that the Diablo Canyon Power Plant's (DCPP's) ground motions from the Shoreline fault are at or below those for which the plant was evaluated previously and demonstrated to have reasonable assurance of safety. This letter provides a summary of the results of the NRC's independent assessment of the information found in the January 7, 2011, report. The staff's more complete assessment is documented in Research Information Letter (RIL) 12-01 "Confirmatory Analysis of Seismic Hazard at the Diablo Canyon Power Plant from the Shoreline Fault Zone" (ADAMS Accession No. ML121230035). In addition, this letter places the NRC's review of the Shoreline fault into context with a recent NRC action to have all of its nuclear power reactor licensees conduct seismic reevaluations. This action is documented in the March 12, 2012, request for information that was sent pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.54(f) (ADAMS Accession No. ML12053A340).

Shoreline Fault Report

On November 14, 2008, PG&E informed the NRC that it had identified a zone of seismicity that may indicate a previously unknown fault located offshore of the DCPP. The potential fault was identified as a result of a collaborative research program between PG&E and the U.S. Geological Survey (USGS). This research program, called the PG&E-USGS Cooperative Research and Development Agreement (CRADA), focuses on increasing the understanding of tectonics in the region around the DCPP.

Shortly after PG&E reported the potential for a new fault, the licensee's representatives provided the NRC with sets of initial scientific data and information related to the hypothesized fault in e-mails dated November 20 and 21, 2008 (ADAMS Accession Nos. ML090690193 and

ML090690218, respectively). PG&E named the hypothesized fault the "Shoreline fault." Based on the information provided by PG&E and the USGS, the NRC performed an independent assessment of this information and documented its review in Research Information Letter 09-001 (RIL 09-001) entitled "Preliminary Deterministic Analysis of the Seismic Hazard at Diablo Canyon Nuclear Power Plant from Newly Discovered 'Shoreline Fault'" (ADAMS Accession No. ML090330523). PG&E was informed of the publication of RIL 09-001 by the NRC staff by letter dated April 8, 2009 (ADAMS Accession No. ML090930459). The NRC's letter stated that the preliminary assessment was that the seismic loading levels for the Shoreline fault were below those for which the plant was previously analyzed. The NRC reviewed information on an ongoing basis as the USGS and PG&E continued to obtain new data as a result of ongoing fieldwork.

In the Shoreline Report dated January 7, 2011, PG&E updated the information that it had provided previously to the NRC staff. In reviewing the complete set of seismological, geological, and geophysical data, the NRC staff worked with independent external experts in the areas of paleoseismology, tectonics, and geology to assess the quality and reliability of the data, to address the broader questions related to regional tectonics, and to develop the five principal interpretations described in RIL 12-01. In addition, NRC staff members and their team of experts visited the site in October 2011 to view the geologic and tectonic features first hand. Based on a review of the report dated January 7, 2011, and the site visit, the NRC Review Team developed an independent assessment of the seismic source characteristics of the Shoreline fault[1] and performed an independent Deterministic Seismic Hazard Assessment as documented in RIL 12-01.

As documented in RIL 12-01, the NRC staff's assessment is that deterministic seismic-loading levels predicted for all the Shoreline fault earthquake scenarios developed and analyzed by the NRC are at, or below, those levels for the Hosgri earthquake (HE) ground motion and the long-term seismic program (LTSP) ground motion. The HE ground motion and the LTSP ground motion are those for which the plant was evaluated previously and demonstrated to have reasonable assurance of safety. Therefore, the staff has concluded that the Shoreline scenario should be considered as a lesser included case under the Hosgri evaluation and the licensee should update the final safety analysis report (FSAR), as necessary, to include the Shoreline scenario in accordance with the requirements of 10 CFR 50.71(e).

Diablo Canyon Seismic Design and Licensing Bases

Three design basis earthquakes were used to develop the seismic qualification basis for plant structures, systems, and components at DCPP:

- *Design Earthquake (DE)* (0.2g) - The amount of vibratory ground motion for which those plant features necessary for continued operation remain functional without undue risk to the health and safety of the public. This is considered to be the equivalent of the operating basis earthquake (OBE) in the licensing basis of the plant.

[1] Based on the data and analysis that the licensee provided, and a determination by the USGS, the "potential" Shoreline fault is treated as a fault for the deterministic analysis documented in RIL 12-01.

- *Double Design Earthquake (DDE)* (0.4g) - The evaluation of the maximum earthquake potential (producing the maximum vibratory ground motion) for which structures, systems, and components needed to prevent or mitigate an accident will remain functional. This evaluation includes all earthquake epicenters within 200 miles and faults within 75 miles of the plant and is considered to be the equivalent to the safe shutdown earthquake (SSE) as described in 10 CFR Part 100, Appendix A.

- *Hosgri Earthquake (HE)* (0.75g) - A postulated 7.5 M earthquake (unique to DCPP) assumed to occur on the Hosgri Fault line. Equipment credited in the HE shutdown path is required to remain functional following a Hosgri design basis earthquake.

Consistent with the DCPP Final Safety Analysis Report Update, Revision 20, the DDE is the equivalent of the SSE at DCPP. When the DCPP Unit 1 license was issued, it included a license condition for PG&E to implement a program to reevaluate the seismic design bases used for DCPP. This license condition led to the development of the LTSP.

Long Term Seismic Program

In compliance with the seismic license condition, PG&E performed a full seismic reevaluation of the DCPP between 1985 and 1988. The licensee performed a seismic margins assessment (SMA) and a seismic probabilistic risk assessment (SPRA) as detailed in the Final Report of the Diablo Canyon Long-Term Seismic Program. The NRC staff's evaluation of this material is documented in NUREG-0675, "Safety Evaluation Report Related to the Operation of Diablo Canyon Nuclear Power Plant, Units 1 and 2," Supplement 34, June 1991. During that reevaluation, the licensee continued to conclude that the Hosgri fault was capable of producing the largest ground motion at DCPP, and, therefore, remained the controlling fault for the seismic design.

The DCPP Final Safety Analysis Report Update states in Section 2.5, "The LTSP contains extensive databases and analyses that update the basic geologic and seismic information in this FSAR Update. However, the LTSP material does not alter the design bases for DCPP." In SSER 34, the NRC states, "The Staff notes that the seismic qualification basis for Diablo Canyon will continue to be the original design basis plus the Hosgri evaluation basis, along with associated analytical methods, initial conditions, etc." The NRC staff concluded in SSER 34 that the DCPP seismic margins are adequate to accommodate the LTSP spectrum.

Information Requested in Accordance with 10 CFR 50.54(f)

In the March 12, 2012, request for information, the NRC staff detailed a two-phase approach related to reevaluating seismic hazards at all power reactor licensees in response to recommendations of the Near-Term Task Force review of the accident at Fukishima Dai-ichi nuclear facility. PG&E is required to take the actions described and respond to this letter. The first phase is to perform a reevaluation of the seismic hazards at the DCPP site using updated seismic information and present-day regulatory guidance and methodologies and then compare

the results to the current seismic design basis. The second phase is based on the results of the first phase and consists of the NRC staff determining whether additional regulatory actions are necessary (e.g., update the design basis and structures, systems, and components important to safety) to provide additional protection against the updated hazards.

Because DCPP is unique in having three earthquake scenarios (DE, DDE, and HE) in its design and licensing basis rather than the normal two (OBE and SSE), the NRC staff expects that the PG&E's response to the March 12, 2012, request for information will compare the updated probabilistic ground motion (i.e., the ground motion response spectrum (GMRS)) with the ground motion in the plant's current licensing basis that is stated as the equivalent of the SSE ground motion. Consistent with the DCPP Final Safety Analysis Report Update, Revision 20, the DDE is the equivalent of the SSE at DCPP. Therefore, for purposes of the response to the March 12, 2012, request for information, the NRC staff expects PG&E to use the DDE for comparison with the reevaluated seismic hazard GMRS.

NRC Staff's Shoreline Fault Assessment in the Context of the March 12, 2012, Request for Information

The NRC recognizes that using the DDE as the basis of comparison will most likely result in the Shoreline fault and the Hosgri earthquake being reported as having greater ground motion than the SSE. The staff has concluded that it is appropriate to include these scenarios, along with any new seismic information that may be developed, in the risk-informed, performance-based GMRS and then follow the process set forth in the March 12, 2012, request for information, to determine whether any additional regulatory action is needed. Changes to the licensing basis may be appropriate to capture the information developed in response to the March 12, 2012, request for information.

It should be reiterated that the NRC staff has concluded that deterministic seismic-loading levels predicted for all the Shoreline fault earthquake scenarios developed and analyzed by the NRC are at, or below, those levels for the HE ground motion and the LTSP ground motion. The HE ground motion and the LTSP ground motion are those for which the plant was evaluated previously and demonstrated to have reasonable assurance of safety. Therefore, the existing design basis for the plant already is sufficient to withstand those ground motions.

The NRC staff understands that the seismic evaluations described in the March 12, 2012, request for information are currently in progress at DCPP, and PG&E plans to acquire new offshore and onshore two- and three-dimensional seismic reflection data to identify and characterize faults in the vicinity of DCPP. If during the collection of the data, new faults are discovered or information is uncovered that would suggest the Shoreline fault is more capable than currently believed, the staff expects that the licensee will provide the NRC with an interim evaluation that describes actions taken or planned to address the higher seismic hazard relative to the design basis, as appropriate, prior to completion of the evaluations requested in the NRC staff's March 12, 2012, request for information. The staff will use this information to independently assess whether the new fault or new information related to the Shoreline fault challenges or changes the staff's current position that the motions associated with the Shoreline fault are at or below those levels of the HE and LTSP ground motions.

For the longer term, consistent with the March 12, 2012, request for information, based on the information from the first phase, the NRC staff will determine whether additional regulatory actions are necessary.

The NRC plans to inform stakeholders of its review of the Shoreline fault and on its continuing review of this matter as additional information becomes available. If you have any questions regarding these evaluations, please contact me at 301-415-1132 or via e-mail at joseph.sebrosky@nrc.gov.

Sincerely,

Joseph M. Sebrosky, Senior Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-275 and 50-323

cc: Distribution via Listserv

For the longer term, consistent with the March 12, 2012, request for information, based on the information from the first phase, the NRC staff will determine whether additional regulatory actions are necessary.

The NRC plans to inform stakeholders of its review of the Shoreline fault and on its continuing review of this matter as additional information becomes available. If you have any questions regarding these evaluations, please contact me at 301-415-1132 or via e-mail at joseph.sebrosky@nrc.gov.

Sincerely,

/RA/

Joseph M. Sebrosky, Senior Project Manager
Plant Licensing Branch IV
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket Nos. 50-275 and 50-323

cc: Distribution via Listserv

DISTRIBUTION:
PUBLIC
LPLIV Reading
RidsAcrsAcnw_MailCTR Resource
RidsNroDserRgs2 Resource
RidsNrrDeEmcb Resource
RidsNrrDorlLpl4 Resource
RidsNrrLAJBurkhardt Resource
RidsNrrPMDiabloCanyon Resource
RidsOgcRp Resource
RidsResDe Resource
RidsRgn4MailCenter Resource

ADAMS Accession No.: ML120730106 *per email

OFFICE	NRR/DORL/LPL4/PM	NRR/DORL/LPL4/LA	NRR/DE/EMCB/BC	NRO/DSEA	NRR/DE	NRR/JLPD/PMB/BC
NAME	JSebrosky	JBurkhardt	MMurphy*	CMunson*	KManoly*	MMitchell*
DATE	10/11/12	4/17/12	9/25/12	9/20/12	4/17/12	9/20/12
OFFICE	RES/DE/SGSEB/BC	OGC	RIV/DRP/RPB-B/BC	NRR//DORL/LPL4/BC	NRR/DORL/LPL4/PM	
NAME	RHogan *	LSubin* NLO	NOKeefe*	MMarkley	JSebrosky	
DATE	9/24/12	9/20/12	9/27/12	10/12/12	10/12/12	

OFFICIAL RECORD COPY

October 14, 2012

P. Michael Payne, Chief, Permits and Conservation Division

Office of Protected Resources, National Marine Fisheries Service

1315 East-West Highway

Silver Spring, MD 20910

ITP.Goldstein@noaa.gov

Objections to the Issuance of an Incidental Harassment Authorization/Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California

Dear Mr. Payne,

Thank you for your attention to concerns raised below regarding the above referenced project.

Purpose:

In light of the October 12, 2012 report "Diablo Canyon Power Plant, Unit Nos. 1 and 2 – NRC Review of Shoreline Fault (TAC Nos. ME5306 and ME5307)" (Attached) it does not appear that additional seismic surveys including offshore airgun blasting is necessary. The objective regarding the seismic potential of the Shoreline Fault has been examined and deemed "safe" by the Nuclear Regulatory Commission.

IHA is inappropriate:

According to the definition of the Incidental Harassment Authorization application (found on the NOAA website http://www.nmfs.noaa.gov/pr/permits/incidental.htm in order to qualify for an IHA, a project must not cause severe injury or death or incorporate mitigations that will negate any possibility of severe injury or death. The above referenced project does not qualify for an IHA because it cannot meet either condition. That said, the project must seek Level A Take Authorization.

Project Description:

The Project Description states the purpose of the project is to, "Obtain high-resolution, deep-imaging of the geometry and *slip rate* [emphasis mine] of the Los Osos fault, as well as the intersection of the Hosgri and Los Osos fault zones in Estero Bay."

In reading the Soils and Geology section of the FEIR, page 4.6-7; "The Los Osos fault zone – The Los Osos fault zone id approximately 31 miles (50 km) long and 1.2 (km) wide, and extends from Estero Bay to the north to an intersection with the West Huasna fault southeast of the city of San Luis Obispo. This fault zone is a system of discontinuous, subparallel faults that has been interpreted by PG&E to have oblique-slip. PG&E has determined a vertical rate of separation across the fault zone of less than 0.1 in/yr (about 0.2 mm/yr) (PG&E 201 1b). "

It appears from land surveys concluded in the last year, PG&E has determined the Los Osos Fault "slip-rate" there is no additional need to investigate via offshore activities.

Additionally, on page 5-4 the EIR states;

"Among the questions to be answered about the faults in the Project area, the following are the most critical for gaining an understanding of the expected type, magnitude, frequency, and duration of ground motion in the project area.

- The slip rate of the Hosgri fault;
- The dip angle of the Hosgri fault;
- The slip rate of the Shoreline fault; and
- The dip angle of the Los Osos fault."

Again, it does not appear that determining "slip rate" of the Los Osos Fault is a component of the offshore testing.

Alternative Technology:

The technology being used is a combination of techniques including airguns, gravimeter and magnetics. Of particular interest is low impact Magnetometer. As stated in the IHA request:

"The *Langseth* will employ a Bell Aerospace BGM-3 geometer, which contains a model G-882 cesium-vapor marine magnetometer (see Figure 6 of the IHA application). Magnetometers measure the strength and/or direction of a magnetic field, generally in units of nanotesla in order to detect and map geologic formations. These data would enhance earlier marine magnetic mapping conducted by the U.S. Geologic Survey (Slither et al., 2009).

The G-882 is designed for operation from small vessels for shallow water surveys as well as for the large survey vessels for deep tow applications. Power may be supplied from a 24 to 30 VDC battery power or a 110/220 VAC power supply. The standard G-882 tow cable includes a Vectran strength member and can be built to up to 700 m (2,297 ft) (no telemetry required). The shipboard end of the tow cable is attached to a junction box or onboard cable. Output data are recorded on a computer with an RS-232 serial port.

Both the gravimeter and magnetometers are "passive" instruments and do not emit sounds, impulses, or signals, and are not expected to affect marine mammals." [Emphasis mine.]

Electromagnetic surveys are ruled out of the Alternatives Analysis of the FEIR, page 5-14, when clearly there would be less environmental impact.

Where is it required that the project imaging has to be 3-D and airguns in excess of 250dB used?

Monitoring is not mitigation:

The project claims a tremendous amount of "Mitigation" will take place, when in fact most of what is described as "mitigation" is actually "monitoring" or "Adaptive Management".

Mitigation as defined by CEQA Section 15370 and should be applied in this case:

"Mitigation" includes:

- *Avoiding the impact altogether by not taking a certain action or parts of an action.*
- *Minimizing impacts by limiting the degree or magnitude of the action and its implementation.*
- *Rectifying the impact by repairing, rehabilitating, or restoring the impacted environment.*
- *Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.*
- *Compensating for the impact by replacing or providing substitute resources or environments.*

The "avoidance" of marine mammals and other sea life when observed for 15-30 minutes as proposed is unacceptable.

Mitigation in the form of cash awards for lost wages for fishermen and related business is not mitigation that benefits the public at large. The collateral damage from lost access to the sea is absent in this project.

Examples of mitigation for the benefit of the public would be something similar to what was built by AT&T 10-15 years ago in Montana de Oro State Park. AT&T directionally bored a fiber optic line along Los Osos Valley Road and through Montana de Oro State Park and out into the sea for a transpacific transmission line. AT&T spent millions of dollars and took years to complete their project, building a road, parking lot and boardwalk to the beach for public access and PG&E's access to the Point Buchon trail in 2007 provided as mitigation for a previous project at Diablo Canyon Nuclear Power Plant. The proposed seismic imaging project mitigates its coastal access damage to the coast in no way.

Environmental Assessment:

Prior to making a final decision on the IHA application, NMFS will either prepare an independent EA, or, after review and evaluation of the NSF EA for consistency with the regulations published by the Council of Environmental Quality (CEQ) and NOAA Administrative Order 216-6, Environmental Review Procedures for Implementing the National Environmental Policy Act, adopt the NSF EA and make a decision of whether or not to issue a Finding of No Significant Impact (FONSI).

Where can one locate and comment on the above referenced **"Independent EA"**?

Additionally, it is said that should any mammal become stranded or killed, the project will cease operation. It is unclear what will happen once the project is halted, necropsy will take place, but the project applicant does not say whether work will resume once the analysis is complete.

The airgun project will send audible blasts into the Morro Bay National Estuary at the mouth of Morro Bay. There is no mention of decibel level or what measures to avoid, monitor or mitigate potential impacts of the project within a nationally protected estuary and the sensitive species that reside there. In particular, the most recent/reduced project impacts on the sensitive species known as the Morro Bay Harbor Porpoise that inhabits "Box 4".

Cumulative Effects

There is no data provided by the applicant related to the cumulative effects of the combined seismic surveys at Diablo Canyon Nuclear Power Plant and San Onofre Nuclear Generating Station. Attached I have complied a count of the two requests for harassment and the effects on the ocean are considerable.

Scientific Data Gathering

NOAA, NMFS, USFWS, CDFG and USGS appear to be excited about the project for its scientific data and study potential related to the ocean species and effects of seismic testing. The fact that low energy seismic testing has been taking place over the past several months within the project area has skewed the baselines and therefore skewing the results from said data and results of said studies. Effects from the low energy testing have been recognized and documented by local fishermen who are familiar with the project area.

Project Timing:

PG&E now claims project mobilization will begin mid-November. The date for close of comments on NOAA's IHA is October 15, 2012. NOAA has up to 45-days to respond to

comments before any approval is given (estimated December 1). USFWS also has a comment period closing on October 26 with another 45- day response period (estimated December 10). The California Coastal Commission will be holding a public hearing on the project on November 14-16, 2012, should the project be approved there will likely be conditions of approval that will have to be met and approved by the Executive Director, after that hearing. It is highly unlikely PG&E will have those conditions met and approved before the end of the year. It is also well known that some species of whale migrate through the project area as early as December 15.

Should the IHA be approved the permit will be in effect for just one year. It does not appear that PG&E will have all regulatory approvals in place by the time the project is set to commence in 2012. Approvals would then be effective for only the fall of 2013. This narrow approval would not be sufficient to complete the seismic studies over the two-year phased project approved by the State Lands Commission.

It would be less than prudent to issue a IHA for any longer period than one year in anticipation of changed circumstances and/or concerns related to results of the seismic surveys once undertaken.

Conclusion:

The project is unnecessary. The use of an IHA is inappropriate due to the admitted impacts identified in the EA. The project description does not reflect the actual project. Less lethal alternative technologies exist. Monitoring is not mitigation. Cumulative impacts including the 1,300 sq. ml. SONGS project are ignored. Low energy seismic surveys have skewed scientific baselines. Project timelines do not reflect real-time migration of sensitive species. The consideration of an IHA must be rejected on its face. The no project alternative is the superior alternative.

Feel free to contact me with any questions you may have.

Sincerely,

Julie Tacker

ITP Goldstein <itp.goldstein@noaa.gov>

Comment letter on Proposed IHA for L-DEO & PG&E Marine Geophysical Survey off the Central Coast of California

Julie Thomas <luzazulmb@gmail.com> Fri, Oct 12, 2012 at 8:15 PM
Reply-To: jthomas56@charter.net
To: ITP.Goldstein@noaa.gov

Dear Mr. Payne - Attached please find the comment letter from the C.O.A.S.T. Alliance regarding the proposed L-DEO and PG&E high-intensity acoustic seismic survey on the central California coast.

Please let me know if you have any questions regarding this submittal.

Thank you very much,

Julie Thomas

Comment ltr to NMFS from COAST Alliance with attach.pdf
8544K

October 12, 2012

P. Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway, Silver Spring, MD 20910

Sent by email c/o ITP.Goldstein@NOAA.gov

Re: Comment Letter on Proposed IHA for Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Dear Mr. Payne:

The C.O.A.S.T.[1] Alliance, a coalition of individuals and organizations from the Central Coast of California and beyond, is writing to express serious concerns about the above-referenced proposed IHA for PG&E's geophy. C.O.A.S.T.'s concern's are due to the potential significant impacts on marine mammals and fisheries of the continuous high-intensity acoustic seismic testing. This letter focuses in particular on the project's impacts on marine mammals and great white sharks. Based on review of the project description and relevant literature, it is clear that the project is not eligible for an Incidental Harassment Authorization pursuant to the Marine Mammal Protection Act (MMPA), because impacts will not be limited to Level B harassment of marine mammals, but will in fact result in significant *Level A* take of marine mammals. In addition, the project poses risk of significant impacts to great white sharks (*Carcharodon carcharias)*, which are being considered for listing as a federally endangered species.

The following are among C.O.A.S.T.'s concerns about the proposed IHA:

1. PG&E's Final Environmental Impact Report (EIR) for the proposed Central Coast seismic imaging project was certified by the California State Lands Commission (SLC) on August 20, 2012, with the finding in their Notice of Determination that *the project will have a significant impact on the environment*. (The EIR and related documents are available on the SLC website at: http://www.slc.ca.gov/division_pages/DEPM/DEPM_Programs_and_Reports/CCCSIP/CCCSIP.html). In regards to impacts on marine mammals, the EIR's Cumulative Impact Analysis states, "Assuming implementation of the APMs and MMs described in more detail in Section 4.4.5 and listed under Impact MARINEBIO-12, the Project would result in significant impacts to fin, humpback, and blue whales; the harbor porpoise; and the Southern sea otter. However, the severity is greatest for the harbor porpoise, even considering the implementation of the APMs and MMs." (p. 4.4-103) (note: APM = Applicant Proposed Measure , and MM = mitigation measure)

   Questions:

   - Under NEPA, is an Environmental Assessment the appropriate environmental review document for a project which will have significant environmental impacts to multiple federally listed marine mammals?
   - Has your office reviewed the comment letter dated August 10, 2012, sent from the Southwest Regional NMFS office to the National Science Foundation (NSF), in which NMFS (page 2/7) states that the project needs a more thorough NEPA analysis? (letter attached). In addition, on page 4/7, SW Reg. NMFS' letter calls NSF's attention to the

[1] C.O.A.S.T. = Citizens Opposing Acoustic Seismic Testing – please see attachments for additional information about the Alliance.

fact that there are inconsistencies between the state and federal analyses regarding impacts to marine mammals. The letter provides further illustrations of multiple apparent shortcomings in the draft EA, inconsistencies with the EIR, or additional analysis that is required. How does your office plan to address the concerns raised by the August 10, 2012 letter sent by the SW Regional NOAA/NMFS office?

2. The Project EIR that was submitted to multiple California agencies predicts Level A take – injury or mortality - for twelve (12) or more marine mammal species, contradicting the draft EA. The proposed project will result in Level A take - injury or mortality - to at least 12 species of marine mammals, according to PG&E's EIR, as described in both Chapters 4 (summarized in Table 4-14) and in Appendix H, the "Marine Mammal Technical Report (summarized in Table 4.1). Below is a summary table of the marine mammals which will be subject to injury or mortality (Level A Take), with take numbers based on data in PG&E's EIR:

Marine mammal species to be impacted by PG&E hi-intensity seismic imaging project per EIR	**Minimum Population Estimate**	**Level A Take estimates (see below for EIR's definition) per Table 4.4-14 in EIR**	
		Minimum	**Maximum**
Fin whale	2,624	2.5	8.9
Humpback whale	1,878	1.2	11.3
Blue whale	2,046	0.9	3.8
Minke whale	202	0.1	0.3
Short-beaked common dolphin	343,990	14.8	28.3
Long-beaked common dolphin	17,127	0.5	1.7
Small-beaked whale species	2,498	<0.1	<0.1
Harbor porpoise	1,478	22.8	51.6
Dall's porpoise	32,106	0.9	1.9
Pacific white-sided dolphin	21,406	1.6	3.0
Risso's dolphin	4,913	0.7	1.7
Northern right whale dolphin	6,019	0.6	1.0
Bottlenose dolphin – CA coastal	290	<0.1	<0.1
Sperm whale	751	<0.1	<0.1
Harbor seal	26,667	7.8	15.1
California sea lion	153,337	501.0	782.7

* **Level A Take as defined by PG&E EIR**: Note that the EIR's criteria for Level A harassment was "both sound exposure over the duration of the survey, or cumulative sound exposure levels (SEL), and marine mammal hearing sensitivities. The cumulative SEL is described in this EIR as the *Injury SEL* when it is used to estimate Level A harassment, which addresses physical injury." (EIR p. 4.4-52)

Questions: Since the Marine Mammal Protection Act (MMPA) authorizes issuance of an IHA only for incidental Level B harassment, and PG&E's EIR "Marine Mammal Technical Report" in Table 4.1 predicts Level A harassment (injury or mortality) of a minimum of

501, and up to 782 marine mammals of at least a dozen different species, wouldn't the project impacts predicted by PG&E's own EIR make the project ineligible for an IHA? How does NMFS plan to address the contradictions between the EIR and the draft EA when making its decision on the IHA?

3. Western gray whales – risk of impacts incorrectly assessed by the EA. Both western and eastern gray whales have been identified as migrating south along the coast of California in the fall, heading toward breeding lagoons in Baja California ("Photographic Comparison of the Western and Mexican Gray Whale Catalogues: 2012", Urban R., et. al. *LSIESP* June 2012) The proposed project will result in potential take of western gray whales, as well as eastern gray whales, in the migration from northern waters to Baja. November and December are regular migration months through the Central California coastal waters for gray whales (citation). This potential impact to western gray whales was not addressed in the EA.

   Question: Was the potential for Level B or Level A take of eastern and western gray whales correctly assessed by EA in their assumption that there would be no migrating whales present during seismic testing?

4. Planned mitigation measures in the draft EA are inadequate to protect marine mammals from Level A take. The mitigation measures planned by PG&E as presented in the draft EA and in the EIR, including aerial surveys, marine mammal observers, scout boats, "ramp-ups" of sound, etc., will still fail to avoid Level A take. The EIR admits this in Table 4.4-18 (p. 4.4-106), where it lists all of the planned mitigation measures and still concludes that "SU" or *Significant and Unavoidable"* impacts to marine mammals and sea otters will occur, as follows:

   a. "Impact MARINEBIO-12: Injury or mortality to marine mammals would occur due to noise during seismic survey acquisition."

   b. "Impact MARINEBIO-13: Injury or mortality to Southern Sea Otters would occur due to noise during seismic survey acquisition"

   Question: What information was presented by the draft EA that adequately addressed, resolved and/or contradicted the above conclusions of the EIR of *Significant and Unavoidable* Level A impacts to marine mammals, including to Southern Sea Otters?

5. The degree of behavioral disruption caused by this project far exceeds the parameters of Level B take, and in fact is likely in many instances to lead to mortality. Given that the project will operate for 24-hours-a-day with seismic discharges every 15 seconds of over 240 decibels for weeks at a time, the behavioral disturbance to marine mammals caused by this project will lead to increased risk of disorientation, disrupted feeding and breeding, relocation, separation of mothers from calves, and temporary hearing damage, and greater exposure to predators for extended periods of time. All of these factors increase risk of mortality, or Level A take.

   Question: Did the EA adequately address the increased risk of mortality posed by the project's "behavioral disruption"? How will the project proponents assess whether any marine mammals have suffered mortality as a secondary consequence of the Level B impacts of the project in the form of disorientation, disrupted feeding and breeding, relocation, separated mothers and calves, temporary hearing damage, and otherwise altered behavior that could potentially expose them to greater predation?

6. Potential impacts to great white sharks, which are being considered by NMFS for federal "endangered" status, were not evaluated by the EA. The EA did not address potential impacts to great white sharks, which are being considered for federal "endangered" status. Fewer than 400 great white sharks are estimated to remain in the northeast Pacific. The proposed project area on the central coast of California hosts prime marine mammal prey species of the great white shark, elephant seals, California sea lions, and harbor seals, among others; in addition, the northern extent of the project area lies within a few miles of a major elephant seal rookery in San Simeon.

   Question: In determining whether to issue an IHA, how will NMFS evaluate the potential of the proposed acoustic seismic testing project to impact the great white shark directly through physical trauma, as well as for its potential to impact the great white shark indirectly through its Level A and Level B impacts (as described in the EIR) to the shark's prey base of marine mammals?

As noted in the points above, the proposed PG&E Central Coast Acoustic Seismic Imaging Project will result in injury or mortality of hundreds of marine mammals, and will do so in violation of the Marine Mammal Protection Act. For this reason, the members of the C.O.A.S.T. Alliance believe that NMFS cannot and should not issue an IHA permit for this project.

Thank you for your time and attention to our comments on this matter.

Sincerely,

Julie Thomas
On behalf of the C.O.A.S.T. Alliance

Email: jthomas56@charter.net
Mail: c/o Mandy Davis, C.O.A.S.T Alliance
P.O. Box 6972
Los Osos CA 93412

Attachments:

- C.O.A.S.T. Alliance Mission Statement
- List of C.O.A.S.T. Alliance Member and Supporter Organizations
- SW Regional NMFS letter to NSF dated 10 August 2012 re proposed IHA
- Excerpts from EIR: Chapter 4.4, Appendix H: Marine Mammal Technical Report

ATTACHMENTS

Member and Supporter Organizations of the C.O.A.S.T. Alliance

C.O.A.S.T. Member and Supporter Organizations	Member/Supporter	ADDRESS/PHONE	WEBSITE	CONTACT PERSON	EMAIL
B-SAGE (Big Sur Advocates for a Green Environment)	Member			Lynda Sayre, Chair	
California Earth Corps	Member				
California Grey Whale Coalition	Member		www.californiagraywhalecoalition.org	Hunter Kilpatrick	defanhk@sbcglobel.net
Cambria Fishing Club	Member	805/927-3364	http://cambriafishingclub.com	Jim Webb Jordan Pavacich	jimwebb3@charter.net jpavacich@yahoo.com
ECO-SLO	Member	3634 Sacramento Dr Ste A San Luis Obispo, CA	http://www.ecoslo.org/	Sandra Marshall	sloinfopress@gmail.com
Environmental Action Committee of West Marin	Member	65 3rd St # 14 Point Reyes Station, CA 94956 415/663-9312	http://eacmarin.org		
EON - The Ecological Options Network	Supporter		http://www.eon3.net	Mary Beth Brangan and Jim Heddle, Co-Directors	
Green Party of Monterey County	Member	PO Box 1851 Monterey, CA 93942	www.greenpartymonterey.org	Larry Parrish	lparrish@toast.net
Hands Across the Water	Member				
Landwatch of SLO County	Member		http://landwatchsloco.org		LandWatchSloCo@yahoo.com
Monterey County Green Party	Member				
Morro Bay Chamber of Commerce	Member	845 Embarcadero, Ste D, Morro Bay, CA 93442	http://www.morrobay.org	Craig Schmidt, CEO	
Morro Bay City	Supporter				

Member and Supporter Organizations of the C.O.A.S.T. Alliance

Council					
Morro Bay Commercial Fishermen's Organization	Member	PO Box 450 Morro Bay, CA 93443 (805) 772-4893	www.womenforfish.org/mbcfo.htm	Tom Roff Mark Tognazzini	salmonfolk@gmail.com mtog@aol.com
Morro Bay Liveaboard Association	Member				
Nevada Nuclear Waste Task Force	Supporter	Las Vegas, NV		Judy Treichal	judynwtf@aol.com
Port San Luis Commercial Fisherman's Association	Member	PO Box 513 Avila Beach, CA 94324		Brian Stacy	bstacy166@yahoo.com
Safe Beach Now	Member		http://safebeachnow.org		SafeBeachNow@gmail.com
Save Our Seas	Member	PO Box 813 Hanalei, HI 96714 808/ 651-3452	www.SaveOurSeas.Org	Capt. Paul Clark - President	SOS@SaveOurSeas.Org
Save the Whales	Member	1192 Waring St. Seaside, CA 93955 831/899-9957	www.savethewhales.org	Maris Sidenstecker, Program Director	maris@savethewhales.org
SLO County Earth Day Alliance	Member	3436 Sacramento Dr San Luis Obispo, CA 544-8529	http://earthdayalliance.com	Molly Johnson Sandra Marshall	earthdayslo@gmail.com
SLO Green Party	Member	PO Box 13244 SLO 93406	www.slo.greens.org	Peggy Koteen 441-5897	pkoteen@aol.com
Three Mile Island Alert	Supporter	315 Peffer Street Harrisburg, PA 17102 717/233-7897	http://www.tmia.com	Scott Portzline	sdportzline1@verizon.net
Western States Legal Foundation	Supporter	655 13th St #201 Oakland, CA 94612 510/839-5877	http://www.wslfweb.org	Jacqueline Cabasso, Executive Director	

C.O.A.S.T. (Citizens Opposing Acoustic Seismic Testing) Alliance

Mission:

The C.O.A.S.T. (Citizens Opposing Acoustic Seismic Testing) Alliance, a diverse coalition of individuals, associations and government and non-government organizations is unified in the goal of ending any efforts to permit and undergo high intensity acoustic seismic testing by PG&E in the regions surrounding the Diablo Canyon Power plant on the central coast of California.

Position Statement:

In recognition of the significant biological impacts and the resulting negative impacts to our coastal economy, C.O.A.S.T. seeks a cessation to all preparations for offshore acoustic testing now in progress and an end to all plans to engage in high intensity acoustic testing as means for seismic mapping. The Alliance further recognizes that testing new faults is not mandated in AB 1632 and that the only legal mandate is to review and assess existing studies and thereby makes the proposed testing superfluous and not a legal requisite to adhere to the legislation. We insist that the permitting process cease in accordance with the fact that an issuance of the permit would not comply with the Coastal Act, Chapter 3 and would be in violation of the Endangered Species Act, the Marine Mammal Protection Act, the California MLPA (Marine Life Protection Act), and the Magnusen-Stevens Fisheries Act, as well as several established international marine conservation laws. Further, we insist that the permitting agencies follow the precautionary principle as it relates to biological communities and recognize their responsibility to the human communities involved and to the devastation that the acoustic seismic testing would wreak on the economy of the Central Coast. We understand and agree that mitigation of said impacts by PG&E is an unacceptable option and cannot be construed as a responsible solution to the impacts of high intensity acoustic seismic testing both now and in the future.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

Holly Smith
National Science Foundation
Division of Ocean Sciences
4201 Wilson Blvd., Room 725
Arlington, VA 22230

AUG 10 2012

Dear Ms. Smith,

NOAA's National Marine Fisheries Service (NMFS) and National Ocean Service (NOS) appreciate the opportunity to comment on the National Science Foundation (NSF) Draft Environmental Assessment (EA) of Marine Geophysical Surveys by the R/V *Marcus G. Langseth* for the Central California Seismic Imaging Project. The proposed action is to conduct a high energy seismic survey in the vicinity of the Diablo Canyon Power Plant and offshore fault zones.

NOAA understands and appreciates the benefits that could come from improved scientific knowledge of major geologic structures and fault zones in the vicinity of Diablo Canyon. We believe this project and our regulatory review would benefit from a more thorough NEPA analysis and we want to work closely with NSF to help improve the EA to better address potential impacts to living marine resources and marine habitats.

In our future work with you we would like to focus on potential impacts to marine mammals and suggestions for improving the analysis of these impacts and ideas to mitigate potential impacts.

In addition, the EA should be revised to improve the analysis of potential impacts to commercial and recreational fisheries and fishery resources including Essential Fish Habitat. We also suggest including a summary of the Endangered Species Act Section 7 consultation process for all species under NMFS jurisdiction. Lastly, we suggest that additional information should be included to characterize the spatial extent of the seismic survey sound field relative to Monterey Bay National Marine Sanctuary which is located in the northern end of the proposed action area, and the extent of activities that would take place in the sanctuary.

We have attached more specific comments from NOS and NMFS.

Thank you for the opportunity to provide input to NSF on this important project and we look

forward to continuing to work with you. If you have any questions for NMFS please contact Ms. Shelby Mendez at shelby.l.mendez@noaa.gov or 562-980-4094, and if you have any questions for NOS and Monterey Bay National Marine Sanctuary please contact Ms. Deirdre Whalen at deirdre.whalen@noaa.gov or 831-647-4207.

Sincerely,

Rodney R McInnis

Rodney R. McInnis
Southwest Regional Administrator
National Marine Fisheries Service

Paul Michel

for William J. Douros
West Coast Regional Director
Office of National Marine Sanctuaries

Office of National Marine Sanctuaries Comments
NSF's Draft EA Marine Geophysical Surveys for Central California
August 10, 2012

Overview Comments

Although the NSF Draft Environmental Assessment acknowledges the presence of Monterey Bay National Marine Sanctuary, ONMS is unable to determine the potential or likely impacts that may occur to sanctuary resources as a result of this project. The Office of National Marine Sanctuaries (ONMS), administered by the National Ocean Service within NOAA, is concerned that the state and federal environmental analyses have come to different conclusions as to whether or not the project will cause significant impacts. Due to the disparity in the environmental analysis, and in the absence of key information, MBNMS staff cannot adequately determine the likely impact to national marine sanctuary resources.

In order to adequately assess the impacts to Monterey Bay National Marine Sanctuary, ONMS requests that NSF increase its level of coordination with our office and provide additional environmental detail on the scope of the project, and the potential impacts that may occur within the boundary of MBNMS.

More specific comments include:

State and Federal environmental analysis

Currently, there are inconsistencies between the state and federal environmental analyses regarding the level of impact to marine mammals. If NSF believes the state analysis is flawed in reaching its conclusion of significant and unavoidable impacts, or if there is additional information that has become available after the NSF Draft EA was released, the final or supplemental environmental analyses will need to explain these differences.

Operations within the National Marine Sanctuary

The Draft EA indicates that the R/V *Marcus G. Langseth* will be operating within MBNMS only when the vessel makes turns. However the sound and potential impact may travel into the sanctuary. Unfortunately, the Draft EA does not address the distance from the sound-source to the sanctuary, how far and at what magnitude these acoustic pulses will travel, and what will be the acoustic profile within the sanctuary from this project. Clear information is needed on the attenuation level, esonification, decibel levels, possible shock wave attenuation, and other relevant acoustic information. In addition, detail is lacking with regard to transects, e.g., when transects will be completed, at what distance from the boundary of Monterey Bay National Marine Sanctuary.

Possible impacts to Sanctuary resources

The Draft EA does not assess impacts to MBNMS resources in a meaningful way. For example, the impact profile in the Draft EA does not comport with the "significant and unavoidable" impacts to harbor porpoise, sea otters and dolphins that were outlined in the state Final EIR. It may be necessary to reduce the size and scope of the project to ensure negative impacts related to

sound are kept beyond the borders of the MBNMS. This critical acoustic data noted above is essential to help NSF, the applicant and ONMS to determine if a broader exclusion area is needed.

Consultation under the NMSA

Federal coordination and consultation under the National Marine Sanctuaries Act Section 304(d) is required for federal agency actions internal or external to a national marine sanctuary for activities that "are likely to destroy, cause the loss of, or injure any sanctuary resource". At present, we are unable to determine if such formal consultation is required without further information as requested above.

National Marine Fisheries Service Southwest Region Comments
NSF's Draft EA Marine Geophysical Surveys for Central California
August 10, 2012

The proposed project is of concern to NMFS because various fish species, essential fish habitat, endangered species, and protected marine mammals, for which NMFS has management or consultation responsibilities under federal statutes, are present within the project area. NMFS offers the following general comments on potential impacts to these resources. NMFS would like to continue to assist the National Science Foundation with developing more detailed analysis of the potential impacts to these resources.

Magnuson-Stevens Fishery Conservation and Management Act Comments

NMFS is concerned that fishing restrictions during the survey period would harm the economic interests of commercial and recreational fishermen and supporting industries operating out of Morro Bay and the Port of San Luis. The proposed action may displace fishing activities to surrounding areas. NSF needs to analyze where this displacement may occur and whether this would create a safety issue for vessels further from their home ports. The Draft EA does not include recreational fisheries data necessary to evaluate economic impacts on local recreational fisheries. There is also concern about the potential short and long term biological impacts on commercially and recreationally important fish species, as well as the potential long-term economic effects to the commercial and recreational fisheries of changes in species abundance. NMFS is concerned about how the proposed action will affect rockfish courtship behavior, which occurs predominantly in the fall, and thus how it might affect larval recruitment in the spring. NMFS is also concerned about the potential for the proposed action to result in increased interactions between the drift gillnet fishery and marine mammals and sea turtles. In order to avoid the noise emitted from the air guns, these animals may move farther offshore than normal and into the area where drift gillnets are routinely placed.

Rec Fish

Essential Fish Habitat

NMFS concurs with the Draft EA's conclusion that essential fish habitat (EFH) would not be permanently impacted by the proposed project. NMFS believes the proposed project would have temporary adverse effects on EFH for various species within the Coastal Pelagic Species, Pacific Coast Groundfish, and Pacific Salmon Fishery Management Plans. The placement of geophones may impact rocky reef, kelp canopy, and seagrass habitats via direct benthic disturbance. However, given the limited spatial extent and linear arrangement of the geophones, any benthic impacts are expected to be temporary and minimal. The acoustic energy generated from seismic testing will temporarily reduce the quality of EFH via increased noise. Potential noise impacts to fishes from the seismic surveys may include mortality, permanent or temporary hearing damage, temporary hearing threshold shifts, and difficulty finding prey or avoiding

predators. However, given the Draft EA's limited quantification of noise impacts to fishes, it is difficult to determine the magnitude of this impact. NMFS believes the Draft EA would benefit by a more robust analysis and/or modeling effort. A more refined impact estimate could be used to determine whether mitigation is appropriate to compensate for impacts to fish populations.

Marine Mammal Protection Act Comments

NMFS is concerned with potential impacts to marine mammals and how the baseline conditions and impacts were evaluated, and consequently how this translates into potential take as defined under the Marine Mammal Protection Act. The density estimates for many of the marine mammal species should be recalculated since the minimum population estimate (N_{min}) was used and may not be appropriate for estimating the level of take, particularly for species like the harbor porpoise (*Phocoena phocoena*). NMFS also recommends that NSF provide justification as to why certain marine mammal species were not included in their analysis while similar species with similar distributions were considered. If take for gray whales is not anticipated nor requested, NMFS recommends that the applicant keep in close communication with NMFS to determine the start of the gray whale migration. NMFS is concerned about the proposed mitigation measures and the effectiveness of these measures for a 24/7 operation as a means to minimize impacts to marine mammals. It appears that different models were used for similar NSF-sponsored seismic surveys. It would be helpful to understand the rationale for adopting one model over the other.

NMFS appreciates the opportunity to provide input to NSF on this important project and we look forward to continuing to work with NSF. If you have any questions please contact Ms. Shelby Mendez at Shelby.L.Mendez@noaa.gov or 562-980-4094.

Chapter 4.4 – Biological Resources – Marine

from Final Environmental Impact Report

Central Coastal California Seismic Imaging Project

4.4 BIOLOGICAL RESOURCES – MARINE

This section evaluates the potential for the Central Coastal California Seismic Imaging Project (Project) to affect marine biological resources, either directly or indirectly, within the Project area and vicinity. Specifically, this section describes the expected impacts associated with Project activities and evaluates the significance of those impacts relative to the existing setting. The analysis considers underwater noise from survey equipment operation, vessel operation, the concentrations and vulnerabilities of sensitive species, and Project scheduling. For the purposes of this Environmental Impact Report (EIR), marine biological resources are defined as marine habitats, and the flora and fauna that occupy them, within the Project area described in Section 2.0 – Project Description. Potential impacts to terrestrial biological resources, including seabirds, are discussed in Section 4.3 – Biological Resources – Terrestrial.

The descriptions of marine biological resources in this section are based on existing literature, relevant public documents, the 2011 Geophysical Survey Permit Application and associated supplemental information submitted by Pacific Gas & Electric Company (PG&E), and Project-specific field surveys conducted on behalf of PG&E including the following:

- 2010 Marine Mammal Monitoring Report;
- 2011 Essential Fish Habitat Assessment (Appendix B to the PG&E Geophysical Survey Permit Application); and
- 2011 Marine Biological Resource and Habitat Report (Appendix C to the PG&E Geophysical Survey Permit Application).

The section begins with a discussion of the existing marine biological setting within the offshore Project area. Following that discussion, the section includes a listing of significance criteria, assesses potential effects to marine biological resources from proposed Project activities, and identifies feasible mitigation measures (MMs) (including Applicant Proposed Measures [APMs]) that would reduce or avoid potentially significant impacts.

4.4.1 Environmental Setting

Marine Habitats

Marine habitat in the Project area consists of a mix of a dynamic intertidal zone and subtidal areas. Daily tidal fluctuations result in frequent periods of sunlight and exposure for the intertidal environment, where wave action influences the type of habitats found within the Project area. Species equipped to withstand the stresses of changing tides and waves tend to be resilient and these intertidal zones host a diverse number of species.

Intertidal Zone

The presence of the Diablo Canyon Power Plant (DCPP) also influences the relative abundance of certain species in the area. Thermal effects on the existing intertidal and shallow subtidal habitats and associated biota within the Project area have been studied since the mid-1970s. As described in the DCPP's annual monitoring and analysis reports submitted to the Regional Water Quality Control Board, long-term changes in Diablo Cove have resulted in a higher proportion of warm-tolerant to cold-tolerant species than other nearby areas that are not influenced by the DCPP (PG&E 2011b).

Rocky inter- and subtidal habitat (+4 feet [1.2 meters (m)] Mean Lower Low Water) and other areas with hard substrate are often rich in species diversity and abundance. Algae, benthic, and sessile organisms attach themselves to permanent, hard substrate, which allows for the establishment of long-lived complex communities (California Department of Fish and Game [CDFG] 2007; PG&E 2011b). For purposes of this EIR, rocky intertidal habitats throughout the Project area are considered sensitive.

The regional inter- and subtidal rocky habitats are characterized as having conspicuous algal cover with scattered clumps of rockweeds (*Fucus* and *Silvetia*) and turfy red alga (*Endocladia muricata*) (Tenera 2010, as cited in PG&E 2011b). Marine algae flourish in the nutrient-rich waters along the coast of California. Sparling (1977) developed a list of over 400 taxa of marine algae in San Luis Obispo County, including the DCPP study area. Iridescent red alga (*Mazzaella flaccida)* are the dominant species in the mid to low intertidal zone. Hollow branch seaweed (*Gastroclonium subarticulatum*), grapestone seaweed (*Mastocarpus papillatus*), and Christmas tree seaweed (*Chondracanthus canaliculatus*) are also abundant in the Project area.

Seagrass beds are found in water depths up to 120 feet (37 m) throughout much of the Project area. One type of seagrass, surf grass (*Phyllospadix* spp.), is the dominant plant in the transition zone between the low intertidal and the shallow subtidal zones, and one of the few flowering plants in the area. Surf grass is considered an important habitat for commercial invertebrates and fish, and is listed by the CDFG as a species of special concern. Some nearshore rocky features could also support stands of surf grass.

Southern California is one of the few places on the western coast of the United States (U.S.) where bull kelp (*Nereocystis luetkeana*) and giant kelp (*Macrocystis pyrifera*) are found together (National Marine Fisheries Service [NMFS] 2011a). While bull kelp is a common surface canopy-forming kelp along the coast in the area of the DCPP, giant kelp occurs in semi-exposed areas, but is typically more abundant in calmer water. More generally, giant kelp forests are the dominant habitat occurring in subtidal areas off the southern California coast where hard or rocky substrate is available. Chainbladder kelp (*Cystoseira osmundacea*), another surface canopy-forming kelp species found in shallower water (less than 30 feet [10 m]), also occurs in the area

(PG&E 2011b). The canopies of all three species develop in the spring and become thickest from summer through fall. Subcanopy structure (less than 3 feet [1 m] off the bottom of the canopy) is provided by tree kelps (*Pterygophora californica* and *Laminaria setchellii*), a perennial species.

Kelp favors nutrient-rich, cool waters that range in temperature from 42 degrees Fahrenheit (ºF) to 72 ºF (5 degrees Celsius [ºC] to 20 ºC). Kelp forests are an important part of the marine ecosystem, providing food, shelter, and nursery habitat for large numbers of invertebrates, fish, shellfish, and marine mammals. Kelp forests also protect coastlines from damaging wave action and provide substrate for many epibiotic, benthic, and sessile organisms (NMFS 2011a).

Foliose, branched, filamentous, and crustose understory species, such as red and brown algae, can be found below the kelp canopies. Articulated coralline algae (*Calliarthron/Bossiella/Serraticardia* complex), a type of red algae, is one of the more common and abundant taxa. Common brown algae include *Dictyoneurum californicum* and *Desmarestia* spp. (PG&E 2011b).

Subtidal Areas

Sandy and muddy bottoms are also found along the coast, but tend to have less diversity than areas with hard substrate. However, certain organisms have become specialized to these subtidal sandy environments, and as such, are important to marine ecosystems. Organisms typically found in the sandy subtidal environments common to the Project area include, but are not limited to: tube worms (*Diopatra ornate*), sand dollars (*Dendraster excentricus*), and various species of crabs, sea stars, snails, and bottom-dwelling fish (PG&E 2011b). In 2008, a Draft EIR for the AT&T Asia American Gateway Project reported three species of seastars (*Asterina miniata, Mediaster aequalis*, and *Pisaster brevispinus*), as well as cancer crabs (*Cancer* sp. and *C. gracilis*) and a sea pen (*Stylatula elongate*) near Montaña de Oro State Park, close to Morro Bay (California State Lands Commission [CSLC] 2008).

Based on a remotely operated vehicle (ROV) survey conducted in June 2011 for the Project, the majority of the seafloor within the five proposed geophone lines was sediment (either coarse or fine sand), with sand waves present in areas. The rocky seafloor habitat within the survey area ranges from high-relief pinnacles and uplifted reefs (maximum estimated elevation is 9 feet [3 m]) to exposed flat bedrock with sand channels, with occasional isolated boulders and larger expanses of boulder habitat. There were no observations in the southernmost geophone alignments due to the presence of kelp in the area selected for survey (PG&E 2011b).

In water depths shallower than 100 feet (30 m), rock features in the surveyed area tend to support macrophytic algae, whereas deeper features generally have a thin veneer of

sediment. Except for occasional aggregations of juvenile rockfish, fish were not common within the rock or sedimentary habitat that was surveyed. Characteristic deeper water epibiota include the plumose anemone (*Metridium senile*), gorgonian corals, and the feather star (*Florometra* sp.), while shallower features support solitary anemones and cup corals (PG&E 2011b).

In 2007, an ROV survey was completed by Applied Marine Sciences (AMS) for the WorldCom Fiber Optic Cable Project (WorldCom), which occurred within the proposed Project area, and described the types of seafloor habitat that would be affected by the Project. The survey found no macroalgae in water depths greater than 100 feet (30 m), and the composition of the epibiota and fish communities varies depending upon substrate type and water depth. The seafloor within 3 miles (4.8 km) of shore is predominantly sediment with high-relief rocky substrate that can reach upward more than 16 feet (5 m).

Estuaries

The Morro Bay Estuary is located in the center of the Project area, approximately 60 miles (97 km) north of Point Conception. The semi-enclosed estuary is 2,300 acres, approximately 4 miles (6 km) long north to south, and is supplied with rich nutrients from creeks (i.e., Chorro and Los Osos Creeks) and springs within the 48,000-acre watershed. Wave action plays a significant role in the transport of coastal sediment in and out of the estuary (U.S. Army Corps of Engineers [USACE] 2003). The mudflats, tidal wetlands, and open water draw an abundance of fish and wildlife, including pickleweed (*S. europeae var. rubra*), eelgrass (*Zostera marina*), steelhead trout, and over 100 species of birds (Morro Bay National Estuary Program [MBNEP] 2000). Morro Bay is a crucial stop on the Pacific Flyway and attracts thousands of migrating birds each year. In 1994, Morro Bay was designated as California's first State Estuary and subsequently accepted into the National Estuary Program in 1995 (MBNEP 2000).

Significant changes have occurred in the watershed surrounding Morro Bay over the last decade. The MBNEP identified sedimentation via erosion, bacterial contamination, and nutrient enrichment as key water quality issues in Morro Bay (MBNEP 2000 and 2005). Bacterial contamination and high levels of nutrients come primarily from failing septic systems, recreational boaters, and urban and agricultural runoff (USACE 2003). In 2003, the MBNEP began mapping the extent of eelgrass communities within Morro Bay. The MBNEP's 2010 *Morro Bay Eelgrass Report* (2010a) stated that eelgrass has declined approximately 27 percent since an apparent peak (344 acres) in 2007. The MBNEP report, *Estuary Tidings 2010*, concluded that conditions are mostly stable; however, Morro Bay faces several challenges, including:

- Degraded habitat and passage barriers for steelhead trout, a species listed under the Federal Endangered Species Act (ESA);

- High levels of bacteria that result in conditions that are not consistently safe for swimming;
- Rapid sedimentation;
- Contaminants; and
- Climate change.

Figure 4.4-1 presents coastal habitats found within the Project area and along California's coast.

Invertebrates

According to photographic stills from the WorldCom EIR, hard-bottom substrate at mid-depths of 148 to 278 feet (45 to 85 m) host invertebrates including bryozoans, red gorgonians (*Lophogorgia chilensis*), and small white colonial anemones. From depths of 148 to 410 feet (45 to 125 m), plumose anemone (*Metridium giganteum*) and brittle stars were observed. In deep water (279 to 410 feet [85 to 125 m]), Morro Group club-tipped anemone (*Corynactis californica*), feather star (*Florometra serratissima*), and lampshells (*Terebratulina*) were observed (Morro Group 1999, as cited in AMS 2008).

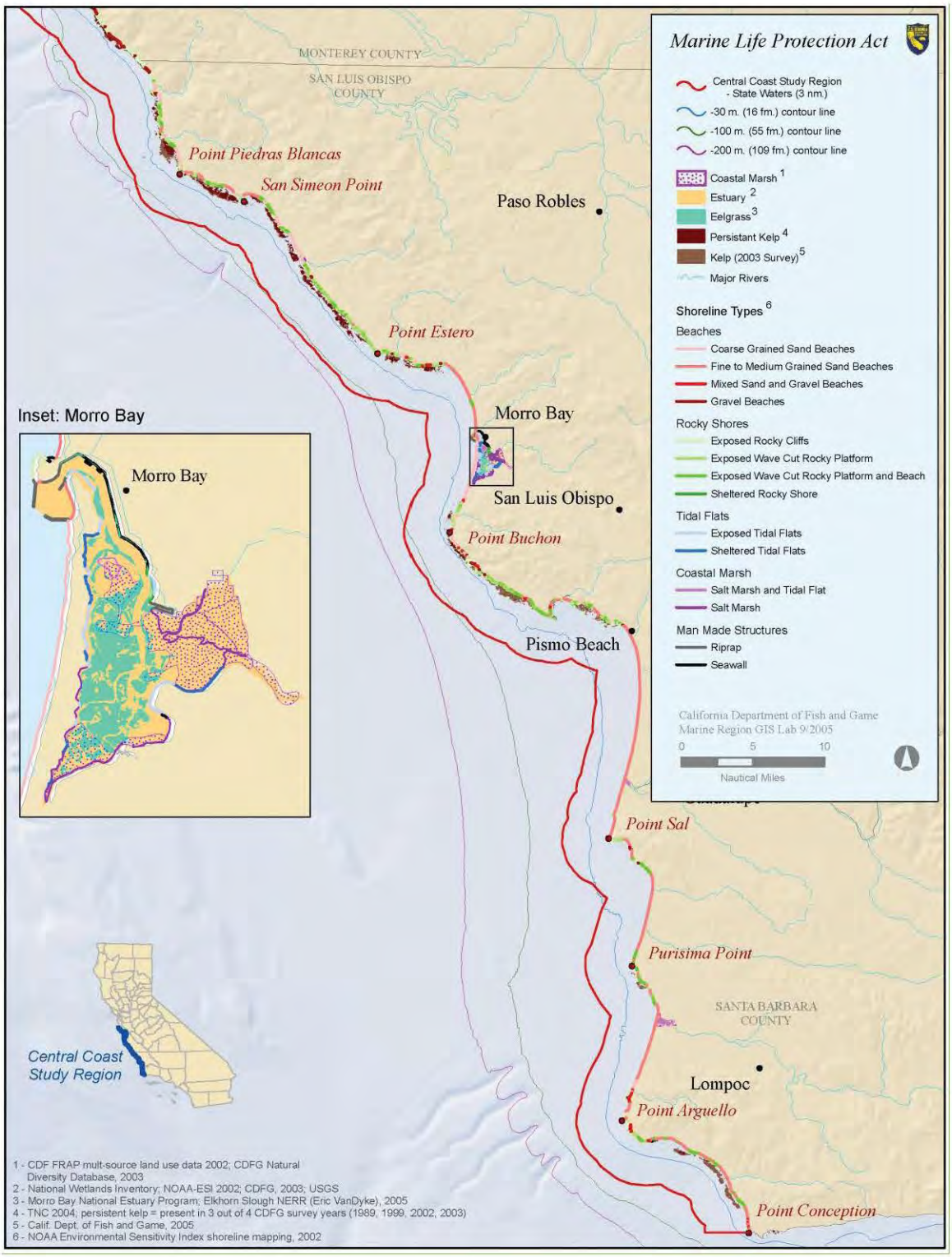
There are four species of abalone, genus *Haliotis*, within central California marine waters, with the most abundant subtidal species being red abalone (*H. rufescens*) (PG&E 2011b). Low population estimates prompted the closure of commercial fisheries for all species in the 1990s and in 2001 (Rogers-Bennett et al. 2002). The white abalone (*H. sorenseni*), typically occurring only south of Point Conception, was listed as endangered under the ESA in 2001.

Red Abalone

Source: http://www.fishtech.com/redab.html

Pinto abalone (*Haliotis kamtshatkana*), an NMFS Species of Concern, is typically found in the intertidal zones within kelp beds north of Point Conception.

Figure 4.4-1 Coastal Habitats Within the Project Area Along the Central California Coast



Source: USCG 2010.

Black abalone (*Haliotis cracherodii),* a relatively large prosobranch gastropod mollusk, may also occur in the Project area. The species has a large range, from approximately Point Arena in northern California to Bahia Tortugas and Isla Guadalupe, Mexico. Black abalone occur in rocky intertidal and shallow subtidal habitats on exposed outer coasts, primarily in crevice microhabitats, and feed preferentially on large drifting fragments of marine algae such as kelps.

Prior to the mid-1980s, black abalone populations around offshore islands in southern California were very large; however, all forms of legal harvest of black abalone were suspended by the State of California in 1993 in response to documentation of population damage caused by withering syndrome. In 2009, the NMFS listed black abalone as endangered under the ESA and in October 2011, the NMFS published a Final Rule on black abalone critical habitat (76 Federal Register [FR] § 66806).

Black Abalone

Source: http://www.nmfs.noaa.gov/pr/species/invertebrates/blackabalone.htm

Invertebrates observed during the 2011 ROV survey conducted for the Project are similar to those species found during the 2007 AMS survey described above. These invertebrate species are listed in Table 4.4-1 below.

Table 4.4-1 Invertebrate Species Observed During the 2011 ROV Survey for the Central Coastal California Seismic Imaging Project

Common Name	Species Name	ROV Survey Location; Depth
Seastar	*Pisaster brevispinus*	Deer Canyon-1; 77 to 91 feet (25 to 30 m)
Anemone	cf *Anthopleura* sp. *and Corynactis californica*	
Encrusting sponges	Unidentified	
Urchin	Unidentified	
Powder puff anemone	*Metridium senile*	Double Rock-1; 77 to 180 feet (25 to 59 m)
Sea cucumber	*Parastichopus* sp.	Double Rock-2; 77 to 180 feet (25 to 59 m)
Gorgonian coral	*cf Lophogorgia chilensis*	
Round encrusting orange sponge	Unidentified (possible *Tethya* sp.)	Double Rock-4 and -5; 77 to 180 feet (25 to 59 m)
Seastar	*Asterina miniata*	Green Peak-21 and -22; 74 to 154 feet (23 to 51 m)
Anemone	*Metridium senile*	

Common Name	Species Name	ROV Survey Location; Depth
Feather stars	*Florometra* sp.	Crowbar Canyon-1; 301 feet (99 m)
Cup corals	Unidentified	Crowbar Canyon-3 and -4; 291 to 314 feet (96 to 104 m)
Sea cucumber	*Parastichopus* spp.	

Source: PG&E 2011b.

Fish

Fish assemblages along the central California coast are comprised of both year-round residents and migratory species. Although some species, such as northern anchovy (*Engraulis mordax*), may be year-round residents, the abundance of these species fluctuates as new cohorts of juveniles migrate inshore or develop from larvae during the spring and summer months. Several factors contribute to the composition of fish species in the area, such as substrate composition, wave exposure, depth, and presence of kelp or seagrass. Many demersal (bottom-dwelling) species inhabit the soft substrates of nearshore zones (depths around 100 feet (30 m) within the Project area, and often include:

- Sanddabs (*Citharichthys* sp.);
- Cuskeels (*Chilara* sp.);
- Tubesnout (*Aulorhynchus flavidus*);
- Rockfish (*Sebastes* sp.);
- California halibut (*Paralichthys californicus*); or
- Pacific staghorn sculpin (*Leptocottus armatus*) (PG&E 2011b).

White croaker (*Genyonemus lineatus*) and barred surfperch (*Amphisticus argenteus*) can be found in the water column, but feed on invertebrates living in the substrate, while species such as anchovy, sardine (*Sardinops sagax*), topsmelts (*Atherinidae* sp.), striped bass (*Morone saxatilis*), or white seabass (*Atractoscion nobilis*) are restricted mainly to the water column where they feed on mid-water plankton or other mid-water fishes (Tenera 2002, as cited in PG&E 2011b).

Grunion (*Leuresthes tenuis*) is a member of the silverside family (Atherinidae) that uses sandy beaches from Monterey Bay to Central Baja California for spawning. Between March and early September, twice a month during new and full moons, grunions come ashore for two or three nights following the highest tide. Grunion bury their eggs 4 to 5 inches (10 to 13 centimeters [cm]) below the surface, with maturation occurring in 10 days. The following spring, when high tide reaches the eggs, hatching is induced and the larvae are carried offshore where they mature. Grunion have the potential to use the

beaches within Estero Bay for spawning and, as such, may seasonally occur within the Project area (CDFG 2011).

Table 4.4-2 Fish Species Found During the 2008 ROV Survey for the AT&T Asia American Gateway Project in Depths Ranging from 100 to 400 Feet (30 to 122 m)

Common Name	Species Name
Shallower Than 100-foot (30-m) Depth	
Cuskeels	*Chilara* sp.
Sanddabs	*Citharichthys* sp.
Tubesnout	*Aulorhynchus flavidus*
Rockfish	*Sebastes* sp.
Northern anchovies	*Engraulis mordax*
Up to 400-foot (122-m) Depth – Sandy Substrate	
Tonguefish	*Symphurus atricauda*
Sanddabs	*Citharichthys* spp.
California halibut	*Paralichthys californicus*
Dover sole	*Microstomas pacificus*
English sole	*Plueronectes [Parophrys] vetulus*
Eelpouts	*Lycodes* sp.
Poachers	*Agonidae*
Cuskeels	*Chilara* sp.
Pink surfperch	*Zalembius rosaceus*
Hagfish	*Eptatretus stouti*
Rockfish	*Sebastes* spp.
Up to 400-foot (122-m) Depth – Rocky Substrate	
Rockfish	*Sebastes* spp.
Lingcod	*Ophiodon elongatus*
Cabezon	*Scorpaenichthys marmoratus*
Painted greenling	*Oxylibius pictus*

Source: Adapted from AMS 2008.

According to a West Coast Groundfish Bottom Trawl Survey conducted by NMFS in the Conception International North Pacific Fisheries Commission unit close to the Project area, species caught within the depths of 603 to 4,199 feet (184 to 1,280 m) include sablefish (*Anoplopoma fimbria*), rex sole (*Glyptocephalus zachirus*), dover sole (*Microstomus pacificus*), longnose skate (*Raja rhina*), splitnose rockfish (*Sebastes diploproa*), stripetail rockfish (*Sebastes saxicola*), spiny dogfish (*Squalus acanthias*), and unspecified catsharks (Keller et al. 2008). The Conception International North Pacific Fisheries Commission unit encompasses the Project area. Only ~~onetwo~~ three listed fish species, the South-Central California Coast Distinct Population Segment

(DPS) of steelhead, ~~and~~ Coho salmon (*Oncorhynchus kisutch*), and the Southern DPS of Green sturgeon (*Acipenser medirostris*), could occur in the vicinity of the proposed Project. In addition, the cowcod *(Sebastes levis)* and bocaccio *(Sebastes paucispinus),* which are listed by the NMFS as Species of Concern, could occur. Descriptions of these species are provided below.

South-Central California Coast Steelhead

South-Central California Coast Steelhead

Source: http://www.nmfs.noaa.gov/pr/species/fish/steelheadtrout.htm

The South-Central California Coast (SCCC) steelhead ~~Distinct Population Segment~~DPS of west coast steelhead trout is a seasonal marine fish species that can occur within the coastal pelagic environment in the south-central California coastal area. The SCCC DPS includes all naturally spawned populations of steelhead in streams from the Pajaro River (inclusive) to, but not including the Santa Maria River (NMFS 1997a, 2006). This species is Federal-listed as threatened. Historical data on the South-Central California Coast steelhead Distinct Population Segment are sparse, although some reports suggest annual historical runs were as high as 27,000 (Moyle et al. 2008). In the mid-1960s, the CDFG estimated that the ~~Distinct Population Segment~~DPS-wide run size was about 17,750 adults (Moyle et al. 2008). No comparable recent estimate exists; however, recent estimates exist for five river systems (Pajaro, Salinas, Carmel, Little Sur, and Big Sur), indicating runs of fewer than 500 adults, where previous runs had been on the order of 4,750 adults (Moyle et al. 2008).

West coast steelhead trout are migratory, anadromous rainbow trout that inhabit streams and rivers from the Santa Maria River south to Malibu Creek (NMFS 2003, NMFS 2007; Stillwater et al. 2008). NMFS has suggested that despite being small, steelhead populations of the Big Sur-San Luis Obispo region are quite resilient based on their high occupancy rate: between 86 percent and 94 percent of these small coastal basins continue to be occupied (NMFS 2005, 2006). Given this information, NMFS (2005) noted that there may be a large amount of interbasin movement of fish in the Big Sur-San Luis Obispo region, effectively linking the various coastal basins into one large population. The five historically highest producing steelhead watersheds (Pajaro, Salinas, Carmel, Little Sur and Big Sur Rivers) (NMFS 2007) are more than 60 nautical miles north of the northernmost survey track (Zone 3).

Only winter steelhead are found in the SCCC steelhead DPS. ~~Juvenile steelhead remain in fresh water anywhere from 1 to 3 years before migrating to sea, usually in the spring. After 1 to 4 years, the trout ascend streams for the first time after reaching~~

~~maturity.~~ Adult ocean-maturing steelhead can~~, however,~~ be found close to the coast of south-central California. Generally, adult SCCC steelhead enter natal coastal streams from December-March, with the peak numbers typically entering natal streams in January/February (Moyle 2002). Timing of upstream migration is correlated with higher flow events and associated lower water temperatures. Smolts and post-spawning adults also out-migrate following winter rains, with peak outmigration occurring in March-May (NMFS 2004, 2007). The pattern of movement and distribution of SCCC steelhead while at sea is poorly understood (NMFS 2007).~~Along the coast in this region, adult winter steelhead typically begin their spawning migration into home streams in late fall and winter and can continue into spring.~~ Spawning takes place from January through May (Moyle et al. 2008; NMFS 2005b).

The winter rains provide increased flows that wash out sandbars that often form at the mouths of coast creeks during periods of low flow, effectively cutting off these coastal streams from the ocean—breaching of these sandbars permits fish passage and also provides large amounts of cold water for SCCC steelhead migration and spawning (Moyle 2002). The *Santa Rosa Creek Watershed Management Plan* reports that the highest monthly mean flows for Santa Rosa Creek occur during the winter/early spring months from January-March (Figure 2-10 of Stillwater Sciences et al. 2012).

Juvenile steelhead remain in fresh water anywhere from 1 to 3 years before migrating to sea, usually in the spring. After 1 to 4 years, the trout ascend streams for the first time after reaching maturity.

Coho Salmon

The coho salmon Central California Coast Evolutionarily Significant Unit (ESU) is a Federal- and State-endangered species. Recent findings of the 5-year review released on August 15, 2011 determined that the Central California Coast coho ESU should remain listed as Endangered.

The coho salmon is an anadromous fish that spends most of its life in the ocean, but returns to freshwater streams to spawn. Coho salmon eggs hatch in freshwater streams and develop as larvae in the streams. As juveniles, they live in freshwater for a period, then migrate to estuarine habitat, and eventually enter the ocean as adults. At around 3 years old, adults return to their stream of origin to spawn and die. Habitat consists of open water with various levels of salinity, depending on their life stage.

Coho Salmon

Source: http://www.nmfs.noaa.gov/pr/species/fish/cohosalmon.htm

The range of the Central California Coast coho salmon ESU includes accessible reaches of all naturally spawned populations of coho from Punta Gorda in northern California south to and including the San Lorenzo River at the north end of Monterey Bay, including two streams entering San Francisco Bay (Arroyo Corte Madera Del Presidio and Corte Madera Creek) (NMFS 1999). As the range for this species is not known to occur as far south as the Project area, this species is extremely rare in the Project area.

In May 1999, critical habitat was designated for the Central California Coast and Southern Oregon/Northern California Coast coho salmon ESUs (NMFS 1999). The Project site does not occur within critical habitat for this species, but adult coho have been observed off of Point Buchon (CDFG 2012b).

Green Sturgeon

Green sturgeon, an anadromous fish species that ranges from southeast Alaska to Mexico, are believed to spend the majority of their lives in nearshore oceanic waters, bays, and estuaries (Beamesderfer 2002; NMFS 2012). The North American green sturgeon have been separated into two DPS:

- Northern DPS (all populations north of, and including the Eel River); and
- Southern DPS (Central Valley and Coastal populations south of the Eel River), a Federal-listed threatened species that is reported to rarely occur in south-central California coastal waters north of Point Conception (NMFS 2002).

Green sturgeon are occasionally caught in Monterey Bay, but the southernmost spawning population is found in the Sacramento River (Moyle 2002; NMFS 2012). Knowledge of current population abundance trends is considered to be limited as contemporary data on green sturgeon comes mainly from fisheries landings (NMFS 2007, 2012).

Adults typically enter freshwaters beginning in late February; spawning occurs from March-July, with peak activity from April through June (Moyle et al. 1995; Moyle 2002). Eggs hatch in 7 to 9 days (at 15°C). Juvenile green sturgeon grow rapidly and spend 1 to 4 years in fresh and estuarine waters before out-migrating to the sea, primarily during the summer and fall (Beamsesderfer and Webb 2002; Moyle 2002). Green sturgeon disperse widely in the ocean after their out-migration from freshwater, generally migrating north (NMFS

Green Sturgeon

Source: http://www.nmfs.noaa.gov/pr/species/fish/greensturgeon.htm#threats

2002; Beamsesderfer and Webb 2002). Although considered limited, existing information suggests that southern DPS green sturgeon are (i) rarely observed in the proposed Project area and (ii) spawning occurs well north of the proposed Project area (NMFS 2012).

Cowcod

Cowcod is a rockfish species that occurs from Ranger Bank and Guadalupe Island in Baja California to approximately Usal, California. In 2000, cowcod was declared overfished after the first assessment of the substock occurring in the Southern California Bight (Pacific Fishery Management Council [PFMC] 2011). Cowcod are found over rocky bottoms, particularly around sharp, steep drop-offs at depths from 60 to 1,200 feet (18 to 365 m). The body of the cowcod is somewhat compressed, with a very large head and sharp dorsal spines.

Cowcod

Source: http://en.wikipedia.org/wiki/Sebastes_levis

Fish, octopus, and squid are prey for adult cowcod, while small shrimp and crabs may also be prey for juveniles. Like all members of the genus *Sebastes*, the cowcod gives birth to live young that can be less than 0.5 inches (1.3 cm) in length. The young may be found in shallower water and are free-floating when born, but they move to deeper water as they grow larger (PG&E 2011b). The establishment of coastwide Rockfish Conservation Areas and Cowcod Conservation Areas south of Point Conception (34º 27º North latitude) has been effective at minimizing cowcod bycatch, though the population is still declining (PFMC 2011).

Bocaccio

Bocaccio

Source: http://www.fishbase.us/summary/Sebastes-paucispinis.html

Bocaccio *(Sebastes paucispinis)* is a large (up to 3 feet [90 cm] in length) rockfish species that occurs from Punta Blanca in Baja California to Kruzof Island and Kodiak Island, Alaska. The southern bocaccio population is listed as a NMFS Species of Concern, likely due to overfishing and poor environmental conditions (NMFS 2009a).

The main hatching period runs from December through April. Juvenile bocaccios (1 to 2 years old) typically travel in loose schools in shallow water. Newly hatched young are less than 2.5

inches (64 millimeters) in length. The species seeks deeper water (250 to 750 feet [76 to 229 m]) and moves from the surface to closer to the seafloor as it ages. Bocaccio have even been found at depths of over 1,000 feet (305 m). Bocaccios prefer irregular substrate with hard or rubble bottom.

The diet of bocaccio includes fish, such as surfperch, jack mackerel, sablefish, anchovies, sardines, and Pacific mackerel; however, this species also consumes squid, octopus, and crab (PG&E 2011b). The PFMC currently has a stock rebuilding plan in place that eliminated directed fishing for the species in 2003 and is estimated to rebuild the bocaccio stock within ~~170~~10 years (PFMC 2011).

Fish Harvested Commercially

Several fish species found within the Project area are targeted commercially (see Table 4.4-3). For a complete description of the commercial fisheries, including species targeted and gear used within the Project area, see Section 4.13 – Commercial Fishing.

Table 4.4-3 Representative Commercially Targeted Species or Species Groups in the Project Area

Target Species or Species Group	
Lingcod	Other Groundfish
P. Cod	Pacific Halibut
P. Whiting	California Halibut
Sablefish	Salmon
Rockfish	Crab
Thornyheads	Pink Shrimp
Arrowtooth Flounder	Ridgeback Prawn
Dover Sole	Spotted Prawn
English Sole	Shrimp
Petrale Sole	Shellfish
Other Flatfish	Other Non-Groundfish
Cabezon	Other Non-FMP Groundfish
Spiny Dogfish	

Source: PFMC 2011.

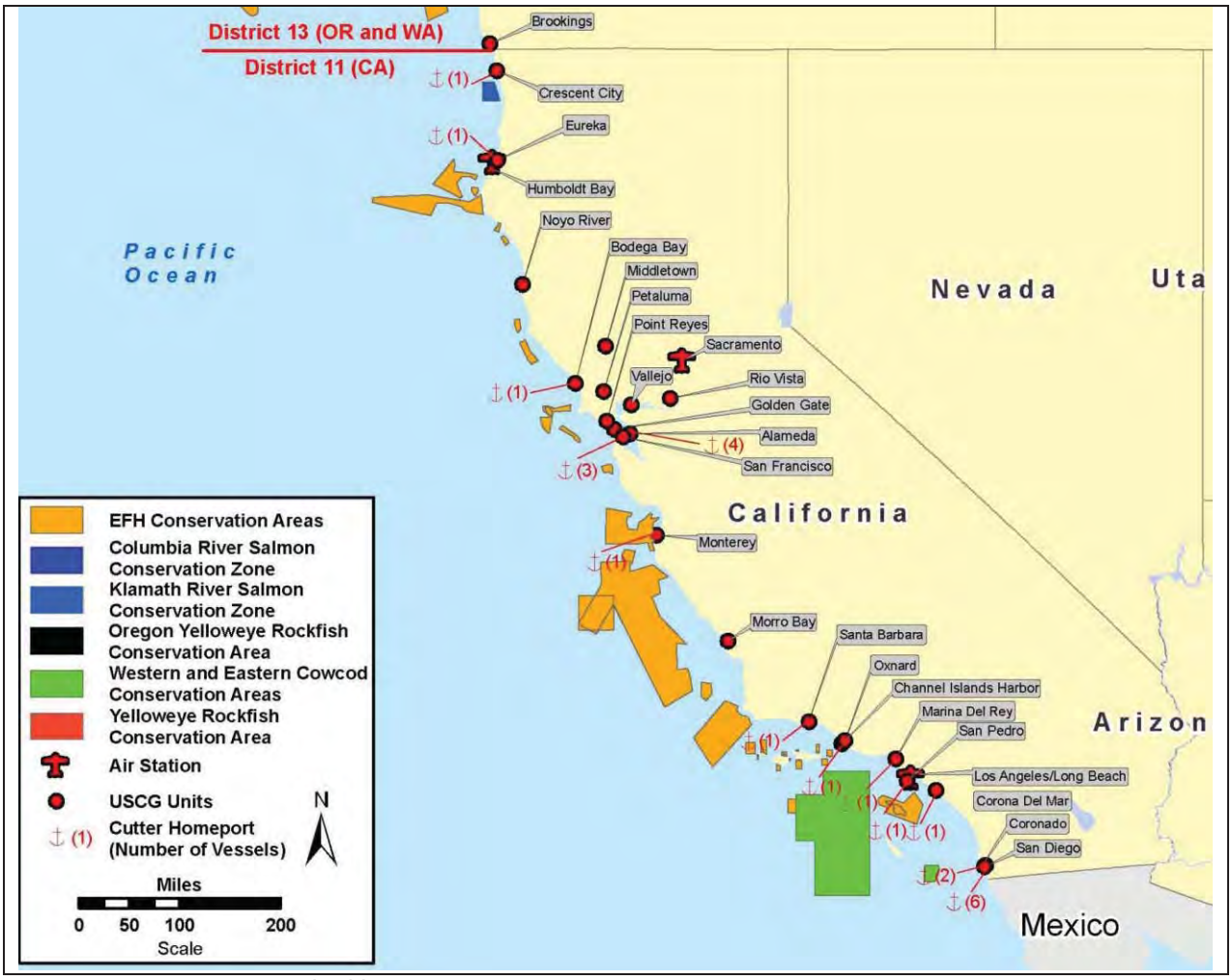
Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act (MSA) defined essential fish habitat (EFH) as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” According to the NMFS, EFH can include sediment, hard bottom, underwater structures, and associated biological communities (PFMC 2005). Section 303, subdivision (a)(7) of the MSA requires fishery management councils to identify EFH. EFH that is judged to be particularly important to

the long-term productivity of populations of one or more managed species, or to be particularly vulnerable to degradation, should be identified as habitat areas of particular concern.

Effective June 12, 2006, EFH protection measures implemented discrete area closures for specific gear types. These closed areas, which are depicted in Figure 4.4-2, were identified by PFMC and are intended to minimize adverse effects of fishing on groundfish EFH (NMFS 2008, as cited in USCG 2010).

Figure 4.4-2 Federal Fishery Management Zones



Source: NMFS 2008, as cited in USCG 2010.

Turtles

Several species of sea turtles occur within waters off the California coast; however, three species are most likely to occur within the Project area: Pacific olive ridley sea turtle (*Lepidochelys olivacea*), leatherback sea turtle (*Dermochelys coriacea*), and green sea turtle (*Chelonia mydas*). Overharvesting and coastal development have greatly

reduced the sea turtle populations throughout the world (Ross 1982). All three species that may occur within the Project area are listed as endangered under the ESA (U.S. Fish and Wildlife Service [USFWS] 2011).

Most of the turtles in the eastern Pacific nest along the coasts of Mexico and Central America, typically in the summer months between May and September. Sea turtles breed at sea and the females return to their natal beaches to lay their eggs. Female turtles can nest several times in a season but this occurs on a 2- to 4-year cycle (i.e., they may not nest every year). After being laid in the sand, the eggs hatch in about two months, and the young instinctively head for the sea (NMFS 2011c; NMFS 2011d; NMFS 2011e).

General distribution and species-specific information are provided in the following paragraphs. Turtle population estimates for California or Pacific waters are located in Table 4.4-4.

Table 4.4-4 Abundance Estimates for Sea Turtles of California

Common Name	Scientific Name	Minimum Population Estimate	Current Population Trend
Green sea turtle	*Chelonia mydas*	3,295 to 3,479 (Eastern Pacific Stock)	Decreasing
Pacific olive ridley sea turtle	*Lepidochelys olivacea*	1.39 million (Eastern Tropical Pacific)	Increasing
Leatherback sea turtle	*Dermochelys coriacea*	178 (California)	Decreasing

Source: NMFS and USFWS 2007a; NMFS and USFWS 2007b; NMFS and USFWS 2007c.

Green Sea Turtle (ESA Threatened)

Green sea turtles are globally distributed and generally found in tropical waters between 30º North and 30° South (NMFS 2011e). Green sea turtles have been reported as far north as Redwood Creek in Humboldt County and off the coasts of Washington, Oregon, and British Columbia (PG&E 2011b). The green sea turtle is thought to nest on the Pacific coasts of Mexico, Central America, South America, and the Galapagos Islands (NMFS and USFWS 2007). There are no known nesting sites along the western coast of the U.S., and the only known nesting location in the continental U.S. is on the eastern coast of Florida (PG&E 2011b).

Green Sea Turtle

Source: http://www.nmfs.noaa.gov/pr/species/turtles/photos.htm#green

Along the southern California coast, green sea turtles are sighted year-round in marine waters, with the highest concentrations occurring from July through September. Recent minimum population estimates for green sea turtles indicate that at least 3,319 individuals are known to occur in the eastern Pacific (NMFS and USFWS 2007a). This population is believed to be increasing (NMFS 2011d).

Green sea turtles spend most of their time foraging along the coast, including areas with open coastline and protected bays and lagoons. Marine algae and seagrass are important constituents of the green sea turtle diet, and some turtles may also forage heavily on invertebrates (e.g., sardines, anchovies, jellies, mollusks, worms, etc.). Red tide may lead to mortality of both juveniles and adults (NMFS and USFWS 2007a).

Loss of beach habitat due to coastal development has directly affected the green sea turtle population and the addition of artificial lighting also contributes to alteration of nesting behavior (Witherington 1992, as cited in NMFS and USFWS 2007a). Problems associated with development in the coastal zone are expected to continue to result in impacts on green sea turtle populations (NMFS and USFWS 2007a).

Pacific Olive Ridley Sea Turtle (ESA Endangered)

The Pacific olive ridley sea turtle was listed as endangered under the ESA on July 28, 1978 (43 FR § 32800). The olive ridley is considered the most abundant sea turtle in the world, with an estimated 800,000 nesting females annually (NMFS 2011e) and is distributed circumglobally (NMFS and USFWS 2007b). The normal range for olive ridley turtles in the eastern Pacific is from Southern California to northern Chile (NMFS and USFWS 2007b). However, because they prefer warmer tropical waters, they are rarely found in southern California and no abundance estimates are available. The California/Oregon drift gillnet fishery has only documented the capture of one olive ridley off southern California, in 1999. Fewer than two olive ridleys per year have been reported stranded in California (23 total, from 1990 through 2002) (Minerals Management Service [MMS] 2005).

Olive Ridley Sea Turtle

Source: http://www.nmfs.noaa.gov/pr/species/turtles/oliveridley.htm

The omnivorous olive ridley sea turtle feeds on fish, crabs, shellfish, jellyfish, sea grasses, and algae, and may dive to considerable depths (260 to 980 feet [79 to 300 m]). Major nesting beaches are located on the Pacific coasts of Mexico and Costa Rica (NMFS and USFWS 2007b).

Perhaps most notable about these turtles is their nesting behavior, where hundreds of thousands of ridleys emerge synchronously on beaches; this

behavior is referred to as an "arribada." Arribadas occur at only a few beaches in the eastern Pacific in Mexico, Nicaragua, Costa Rica, and Panama from June through December (NMFS and USFWS 2007b).

The population on Pacific beaches in Mexico has declined from an estimated 10 million adults in 1950 to fewer than 80,000 in 1983 due to excessive over-harvesting (PG&E 2011b). At-sea density and abundance estimates were conducted in 2006 and a weighted average of yearly estimates was 1.39 million (NMFS and USFWS 2007b). Conservation measures, such as increased nesting beach protection and closure of the turtle fishery in 1990, have led to a dramatic increase in the once-largest nesting population in the world. The number of olive ridley nests has increased from 50,000 in 1988 to over 700,000 in 1994 to more than a million nests in 2000 (PG&E 2011b). The eastern tropical Pacific population is estimated at 1.39 million, which is consistent with the dramatic increases of olive ridley nesting populations that have been reported (NMFS and USFWS 2007b).

Leatherback Sea Turtle (ESA Endangered)

The leatherback sea turtle was listed as endangered throughout its range on June 2, 1970 (35 FR § 8491) and on January 26, 2012, the NMFS published a Final Rule revising leatherback sea turtle critical habitat to include additional areas within the Pacific Ocean (77 FR § 4170). Critical habitat now extends approximately 16,910 square miles (43,798 square km) from Point Arena to Point Arguello in California, which includes the offshore Project area. Leatherbacks are commonly known as pelagic (open ocean) animals and are the most migratory and wide-ranging species of sea turtle. Leatherbacks have the most extensive range of any living reptile and have been reported circumglobally throughout the oceans of the world (NMFS 2009b). Occurring at latitudes as high as 71° North and 47° South, leatherbacks can forage in the cold temperate regions of the oceans; however, nesting is confined to tropical and subtropical latitudes. Their extensive latitudinal range is due to their ability to maintain warmer body temperatures in colder waters (NMFS 2009b).

These turtles depend on coastal waters for foraging. Leatherbacks mate in the waters adjacent to nesting beaches and along migratory corridors. After nesting, female leatherbacks migrate from tropical waters to more temperate latitudes, which support high densities of jellyfish prey in the summer (NMFS 2009b).

Leatherback Sea Turtle

Source: http://www.nmfs.noaa.gov/pr/species/turtles/photos.htm#leatherback

Leatherbacks forage off central California, generally at the end of the summer, when upwelling relaxes and sea surface temperatures increase (MMS 2005). Leatherback sea turtles are the most common sea turtle off the western coast of the U.S. (NMFS 2009b). Stranding reports from 1990 through 2002 for California reveal that the leatherback is the second-most commonly stranded sea turtle, with an average of nearly five per year (MMS 2005).

Off the western coast of the U.S., leatherback sea turtles are most abundant from July to September. It has been noticed that their appearance off this coast is “two-pronged,” with sightings occurring in northern California, Oregon, Washington, and southern California, with few sightings occurring along the intermediate coastline. In southern California waters, leatherback sea turtles are most common between the months of July and September, and in years when water temperatures are above normal. In January 2010, the NMFS submitted a proposal to revise the current habitat for the leatherback sea turtle to include the coastal areas between Point Arenas and Point Vicente in California.

Leatherback sea turtles are omnivores, but feed principally on soft prey items such as jellyfish and planktonic chordates (e.g., salps). Recent population estimates for eastern Pacific leatherback sea turtles indicate that at least 178 individuals are known to occur off California. This population is believed to be decreasing worldwide; however, nesting trends on U.S. beaches have been increasing in recent years (PG&E 2011b).

Dutton estimated that, based on preliminary data analysis, leatherbacks spend 75 to 90 percent of their time at depths of less than 262 feet (80 m) (NMFS 2009b). Within neritic central California waters, leatherbacks spend approximately 50 percent of their time at or within 3 feet (1 m) of the surface while foraging and over 75 percent of their time within the upper 16 feet (5 m) of the water column (NMFS 2009b).

Current research has shown that leatherbacks clearly target the dense aggregations of brown sea nettle (*Chrysaora fuscescens*) that occur near the central California coast and north through Washington during summer and fall. Leatherbacks have also been observed foraging on other scyphomedusae in this area, particularly moon jellies (NMFS 2009b).

In 2007, the NMFS received a petition to revise the leatherback critical habitat designation to include waters off the western coast of the U.S. In December 2007, the NMFS published a 90-day finding on the petition, followed by a proposed rule to revise the critical habitat designation on January 5, 2010 (75 FR § 319).

Marine Mammals

There are a total of at least 22 species of cetaceans (whales and dolphins), six species of pinnipeds (seals, fur seals and sea lions), and one species of fissiped (sea otters) found along the central California coast (see Table 4.4-5). The abundance of many of these species varies seasonally, while some pinnipeds and dolphins are considered year-round residents. Several species of whales migrate through the area (e.g., gray whales [*Eschrichtius robustus*]) or are most common during specific months (e.g., blue whales [*Balaenoptera musculus*] and humpback whales [*Megaptera novaengliae*] are most abundant in the summer months) (Rugh et al. 2001; Peterson et al. 2006; Bailey et al. 2010; PG&E 2011b). Both permanent residents and migrants could occur within the Project area.

Table 4.4-5 Abundance Estimates for Marine Mammals of California

Common Name *Scientific Name*	Minimum Population Estimates
Mysticeti	
California gray whale *Eshchrichtius robustus*	19,126 (Eastern North Pacific stock)
Fin whale *Balaenoptera physalus*	2,624 (California/Washington/Oregon stock)
Humpback whale *Megaptera novaeangliae*	1,878 (California/Washington/Oregon stock)
Blue whale *Balaenoptera musculus*	2,046[a] to 2,842[b] (Eastern North Pacific stock)
Minke whale *Balaenoptera acutorostrata*	202 (California/Washington/Oregon stock)
North Pacific right whale *Eubalaena japonica*	17[c] (Eastern North Pacific stock)
Sei whale *Balaenoptera borealis*	83 (Eastern North Pacific stock)
Odontoceti	
Short-beaked common dolphin *Delphinus delphis*	343,990 (California/Washington/Oregon stock)
Long-beaked common dolphin *Delphinus capensis*	17,127 (California stock)
Striped dolphin	8,231 (California/Oregon/Washington)
Dall's porpoise *Phocoenoides dalli*	32,106 (California/Washington/Oregon stock)
Harbor porpoise *Phocoena phocoena*	1,478 (Morro Bay stock)
Pacific white-sided dolphin *Lagenorhynchus obliquidens*	21,406 (California/Washington/Oregon stock)

Common Name *Scientific Name*	Minimum Population Estimates
Baird's beaked whale *Berardius bairdii*	615[d] (California/Oregon/Washington stock)
Cuvier's beaked whale *Ziphius cavirostris*	1,298 (California/Oregon/Washington stock)
Risso's dolphin *Grampus griseus*	4,913 (California/Washington/Oregon stock)
Northern right whale dolphin *Lissopelphis borealis*	6,019 (California/Washington/Oregon stock)
Bottlenose dolphin *Tursiops truncatus*	684 (290 in Coastal California population)
Sperm whale *Physeter macrocephalus*	751 (California/Washington/Oregon stock)
Short-finned pilot whale *Globicephala macrorhynchus*	465 (California/Washington/Oregon stock)
Killer whale *Orcinus orca*	86[d] (eastern North Pacific southern resident stock) 162[d] (eastern North Pacific offshore stock 346 (eastern North Pacific transient stock)
Pinnipedia	
California sea lion *Zalophus californianus*	153,337[d] (U.S. stock)
Northern elephant seal *Mirounga angustirostis*	74,913 (California stock)
Pacific harbor seal *Phoca vitulina richardsi*	26,667 (California stock)
Northern fur seal *Callorhinus ursinus*	5,395 (San Miguel Island stock)
Guadalupe fur seal *Arctocephalus townsendi*	3,028 (Mexico to California stock)
Northern (Steller) sea lion *Eumetopias jubatus*	2,479 (California population)
Fissipedia	
Southern sea otter *Enhydra lutris nereis*	2,711[e] (California stock)

Source: NMFS 2011a; [a] NMFS 2010c; [b] Calambokidis 2009; [c] Based on photo identification; [d] NMFS 2011r; [e] USGS 2010.

Based on decades of data collection on marine mammal abundance along California's coast, Table 4.4-6 provides a general characterization of seasonal occurrence of species that could be present within the Project area. It is important to note that although there are clear patterns of occurrence as shown, individual animals also may be found within the area during the "off" season.

Table 4.4-6 Marine Mammal Species Primary Periods of Occurrence[1]

	Month of Occurrence											
Common Name	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Family *Mysticeti*												
California gray whale												
Blue whale (E)												
Fin whale (E)												
Humpback whale (E)												
Minke whale												
Sei whale												
North Pacific right whale (E)												
Family *Odontoceti*												
Short-beaked common dolphin												
Dall's porpoise												
Harbor Porpoise												
Long-beaked common dolphin												
Pacific white-sided dolphin												
Risso's dolphin												
Short-finned pilot whale												
Bottlenose dolphin												
Northern right whale dolphin												
Killer Whale												
Family *Pinnipedia*												
Northern fur seal												
California sea lion												
Northern elephant seal												
Steller sea lion (T)												
Pacific harbor seal												
Guadalupe fur seal[2]												
Family *Fissipedia*												
Southern sea otter (T)(5)												

Key: Relatively uniform distribution; Not expected to occur; More likely to occur due to seasonal distribution

NOTES:

[1]This table provides general information on the primary period of occurrence of species found within or near the Project area, but some variation may exist. Individual animals, while not expected to occur, may be observed within the area outside of the primary period of occurrence.

[2]Little is known about the distribution of Guadalupe fur seals during the non-breeding season (September to May) (National Science Foundation [NSF] 2011).

Sources: Bonnell and Dailey 1993; NMFS 2009c; National Centers for Coastal Ocean Science (NCCOS) 2007, adapted from PG&E 2011b.

Pacific harbor seal, California sea lion, and Steller sea lions have haul-out and rookery sites within or in close proximity to the Project area.

Marine wildlife monitoring during geophysical surveys conducted over 76 days between December 2010 and February 2011, inclusive, within the Project area reported several marine mammal species, as summarized in Table 4.4-7. Species were documented while vessels were in transit and during the geophysical survey, as noted in the table.

Table 4.4-7 Summary of Marine Mammals Recorded in the Project Area During 2010-2011 Survey

Common Name	Transit (# of individuals*)	Survey (# of individuals*)	Total (# of individuals*)
Southern sea otter	673	29	702
California sea lion	219	286	505
Risso's dolphin	9	355	364
Common dolphin	41	103	144
Gray whale	26	26	52
Harbor seal	36	11	47
Harbor porpoise	37	2	39
Humpback whale	4	8	12
Dall's porpoise	0	10	10
Right whale dolphin	0	10	10
Unidentified mammals	7	1	8
Minke whale	1	1	2
Killer whale	0	2	2
Total	*1,053*	*844*	*1,897*

Notes: * Multiple observations of the same individuals could have occurred.
Source: PG&E 2011b.

The following information provides a brief summary of each species that may occur within the Project area.

Cetaceans (Whales, Dolphins, and Porpoises)

Mysticeti

There are three families of baleen whales (mysticetes) that occur off the coast of central California, including gray whales, northern right whales, and members of the rorquals family (*Balaenopteridae*). Rorquals include blue whales, fin whales, humpback whales, and minke whales and are characterized as having pleated throats that expand to take in water which is then strained outward through the baleen.

Baleen whales range widely in the North Pacific, spending about 4 to 6 months in the summer in productive waters at high latitudes. The remaining months are spent migrating to winter calving grounds in the south, although individual species' patterns may vary. During the southbound migration, the mating season begins and generally lasts through winter. Shrimp-like invertebrates known as zooplankton comprise the baleen whale diet (Bonnell and Dailey 1993, as cited in PG&E 2011b). Some species also take small schooling fishes and squid. Larger rorquals, such as the blue whale, appear to feed mainly on large crustaceans such as krill. Gray whales feed on invertebrates that live in the sediment such as amphipods and marine worms.

Several species of mysticetes have the potential to occur within the Project area or to be encountered by vessels traveling to the Project area. Mysticeti have shown localized avoidance to seismic exploration sound (Malme et al. 1984). The species with the highest potential to be encountered during Project activities are detailed below.

Gray Whale (Delisted from ESA)

Gray Whale

Source:http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/graywhale.htm

The Eastern North Pacific stock of gray whales breeds and calves in lagoons along the west coast of Baja California and in the Gulf of California in the winter (Rice and Wolman 1971, as cited in NMFS 2010a). The northbound migration typically begins in mid-February and continues through May when the population begins a 5,000-mile (8,000-km) coastal migration to summer feeding grounds to the north (NMFS 2010a). Migrating gray whales generally travel within 3 nautical miles (nm) (6 km) of the coast and would pass through the area in less than 24 hours (Rugh et al. 1999; 2001). The southward migration generally occurs from December through February and peaks in January. On June 15, 1994, gray whales were removed from the endangered species list. The most recent population estimates of eastern North Pacific gray whale indicate that approximately 19,126 individuals are known to occur (NMFS 2010a). The population size of the Eastern Pacific gray whale stock has been increasing over the past several decades (NMFS 2010a).

Humpback Whale (ESA Endangered; MMPA Depleted)

Humpback whales feed in the coastal waters of the North Pacific from California to Russia and in the Bering Sea. They migrate south to wintering destinations off Mexico, Central America, Hawaii, southern Japan, and the Philippines (NMFS 2010b). Humpback whales were listed as endangered under the ESA in 1973 due to historic whaling that took approximately 8,000 whales from the west coast of Baja California between 1919 and 1987 (Rice 1978, as cited in NMFS 2010b).

Humpback whales are distributed mostly over shelf and slope habitats and are more frequently sighted off central California from March through November, with peaks in the summer and fall (PG&E 2011b). Humpback whales switch between krill and forage fish, but also show large inter-annual variations in density and location (Peterson et al. 2006; Calambokidis et al. 2008). According to Bonnell and Dailey (1993, as cited in PG&E 2011b), humpback whales migrating through central California appear to travel closer to shore than blue or fin whales.

Humpback Whale

Source:http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/humpbackwhale.htm

A 2007/2008 Petersen mark-recapture study yielded an estimate of 2,043 humpback whales in California and Oregon, the largest estimate to date (Calambokidis 2009). Although the overall rate of increase over the past 10 years has been approximately 8 percent, there have been a lower number of recaptures, thus potentially biasing abundance estimates. Despite this, the population is anticipated to be increasing (NMFS 2010b). Locally high abundances could occur within the Project area if and when suitable foraging conditions are present (NCCOS 2007). Humpbacks often take advantage of inshore fall (September/October) concentrations of anchovy/sardines. According to marine wildlife surveys conducted by PG&E (2011) from October 24 to December 17, 2010, and from January 5 to February 5, 2011, a total of 12 humpback whales were observed within the Project area. The species is still listed as “endangered,” and, consequently, the California/Mexico stock is automatically considered as a “depleted” and “strategic” stock under the Marine Mammal Protection Act (MMPA).

Blue Whale (ESA Endangered; MMPA Depleted)

Blue whales were listed as endangered under the ESA in 1973 due to intensive historical commercial whaling. Blue whales are distributed worldwide in circumpolar and temperate waters, and inhabit both coastal and pelagic environments (Leatherwood et al. 1982; Reeves et al. 1998a, as cited in NMFS 2010c).

Blue Whale

Source:http://marinebio.org/species.asp?id=41

Like most baleen whales, they migrate between warmer waters used for breeding and calving in winter and high-latitude feeding grounds where food is plentiful in the summer. Most of this stock is believed to migrate south to spend the winter and spring in high productivity areas off Baja California, in the Gulf of California, and on the Costa Rica Dome. Given that these migratory destinations are areas of high productivity and given the observations of feeding in these areas, blue whales can be assumed to feed year-round.

High inter-annual density variability has been documented for California waters (Calambokidis et al. 2004; 2008; Peterson et al. 2006). In 2009, Calambokidis reported a total of 437 identifications of blue whales along the West Coast from Baja to Washington, with almost half coming from the Santa Barbara Channel between June and December. NMFS (2010c) reported a minimum population estimate for blue whales of approximately 2,046, while Calambokidis (2011 pers. comm.) reported an abundance estimate of 2,497. A maximum estimate of approximately 100 blue whales is likely to be within the Project area in early fall (Calambokidis 2011). While concentrations of this scale do not occur regularly, it reflects the variation in foraging opportunities in the Project area that can occur from year to year.

Minke Whale (MMPA Protected)

Minke whales (*Balaenoptera acutorostrata scammoni*) are a coastal species that are widely distributed on the continental shelf throughout the eastern North Pacific (Green et al. 1989, as cited in PG&E 2011b). In California and the Gulf of California, minke whales occur year-round (Dohl et al. 1983; Forney et al. 1995; Barlow 1997; Tershy et al. 1990, as cited in NMFS 2010d). The “resident” population that occurs in coastal waters along California, Oregon, and Washington is considered a separate stock from those animals that migrate further north (NMFS 2010d). The minimum population estimate for minke whales is estimated from 2005 and 2008 summer/fall ship surveys in California, Oregon, and Washington waters (Barlow and Forney 2007; Forney 2007; Barlow 2010, as cited in NMFS 2010d) and is approximately 202 whales. There are no

data on trends in minke whale abundance in waters of California, Oregon, and/or Washington. Minke whales are not listed as "endangered" under the ESA and are not considered "depleted" under the MMPA. This species favors shallow water and ventures near shore more often than other baleen whales (Watson 1981, as cited in PG&E 2011b). The greatest uncertainty in their status is whether entanglement in commercial gillnets and ship strikes could have reduced this relatively small population. Two minke whales were observed from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (PG&E 2011b).

Minke Whale

Source:http://marinebio.org/species.asp?id=230

North Pacific Right Whale (ESA Endangered; MMPA Depleted)

Like many other large whales species, the North Pacific right whale (*Eubalaena japonica*) was listed as an endangered species under the Endangered Species Conservation Act (ESCA), the precursor to the ESA, as a result of intensive historical commercial whaling~~, and retains its endangered status today~~. The North Pacific right whale is listed as an endangered species under the ESA, depleted under the MMPA, and a fully protected species under section 4700, subdivision (b)(6), of the California Fish and Game Code. Only 82 North Pacific right whales were sighted in the Bering Sea and adjacent areas of the Aleutian Islands (Brownell et al. 2001, as cited in NMFS 2010e) between the mid-1960s to the late 1990s, following a period of intense illegal whaling by the U.S.S.R. Sightings have been reported as far south as central Baja California in the eastern North Pacific, as far south as Hawaii in the central North Pacific, and as far north as the sub-Arctic waters of the Bering Sea and Sea of Okhotsk in the summer (Herman et al. 1980; Berzin and Doroshenko 1982; Brownell et al. 2001, as cited in NMFS 2010e).

North Pacific Right Whale

Source:http://en.wikipedia.org/wiki/North_Pacific_right_whale

While North Atlantic (*E. glacialis*) and Southern Hemisphere (*E. australis*) right whales have been documented to calve in coastal waters during the winter months, no such calving grounds have been identified for North Pacific right whales. Migratory patterns of North Pacific right whales are unknown, although it is thought they migrate from high-latitude feeding grounds in summer to more temperate waters during the winter, possibly well offshore (Braham and Rice 1984; Scarff 1986; Clapham

et al. 2004, as cited in NMFS 2010e). According to Wade et al. (2011) this species is assumed to spend of the summer months in Alaskan waters. Although an estimate of abundance is not currently available, the minimum estimate is 17 based on photo-identification of uniquely identifiable individuals (NMFS 2010e).

Fin Whale (ESA Endangered; MMPA Depleted)

Fin whales (*Balaenoptera physalus*) were listed as endangered under the ESA and consequently "depleted" under the MMPA in 1976. The historic population is thought to have been approximately 42,000 to 45,000 prior to commercial whaling (Ohsumi and Wada 1974, as cited in NMFS 2010f). Acoustic signals from fin whales are detected year-round off northern California, Oregon, and Washington, with a concentration of vocal activity between September and February (Moore et al. 1998, as cited in NMFS 2010f).

Fin Whale

Source:http://marinebio.org/species.asp?id=40

Fin whales in the Gulf of California appear to be an evolutionarily unique population according to genetic studies that show it is isolated from fin whales in the rest of the eastern North Pacific (Bérubé et al. 2002, as cited in NMFS 2010f). The most recent estimate of the fin whale population is a minimum of approximately 2,624 whales (NMFS 2010f). There is some evidence that recent increases in fin whale abundance have occurred in California waters, but these have not been statistically significant (Barlow 1994 and 1997, as cited in NMFS 2010f).

Sei Whale (ESA Endangered; MMPA Depleted)

The sei whale (*Balaenoptera borealis*) is listed as an endangered species under the ESA and as "depleted" under the MMPA. Sei whales were historically abundant off of the California coast and were the fourth-most common whale taken by California coastal whalers in the 1950s and 1960s. Prior to whaling, sei whale population estimates may have been around 42,000 (Tillman 1977) or may have ranged as high as 58,000 to 62,000 (Ohsumi and Wada 1974, as cited in NMFS 2010g). According to the NMFS (2011, as cited in PG&E 2011b), they are now considered "extraordinarily" rare.

Sei Whale

Source:http://marinebio.org/species.asp?id=192

The minimum population estimate of the northern Pacific sei whale stock is approximately 83 individuals (NMFS 2010g). Sei whales occur throughout most temperate and subtropical oceans of the world. The

northern Pacific stock rarely ventures above 55° North or South of California (Allen et al. 2011, as cited in PG&E 2011b). Like most baleen whales, they migrate between warmer waters used for breeding and calving in winter and high-latitude feeding grounds where food is plentiful in the summer. The northern Pacific stock ranges almost exclusively in pelagic waters and rarely ventures into coastal waters (Allen et al. 2011, as cited in PG&E 2011b). Sightings of sei whales have mainly been in deeper, offshore waters of Northern California and Oregon, with no confirmed sightings made within 200 km of the Project area (Carretta et al. 2010).

Odontoceti

Odontocetes, or toothed whales, commonly found in the central California waters include sperm whales, at least six species of beaked whales, several species of dolphins, porpoises, and other small whales as described below. With the exception of killer whales, which are the top predators in the ocean and feed on a wide variety of fishes, squid, pinnipeds, and cetaceans, odontocetes generally feed on schooling fishes and squid (Bonnell and Daile 1993, as cited in PG&E 2011b). Major fish prey species include anchovy, mackerel, lanternfish, smelt, herring, and rockfishes. Octopus and crustaceans are also eaten on occasion. The species with the highest potential to be encountered during Project activities are discussed below.

Common Dolphins (No Listings)

Common dolphins are found worldwide and are the most abundant cetaceans in California waters (PG&E 2011b). Two recognized species of common dolphin are found in central California waters.

The long-beaked common dolphin (*Delphinus capensis*) is commonly found within about 48 nautical miles (nm) (90 km) from the coastline. Its relative abundance changes both seasonally and inter-annually, with the highest densities observed during warm water events (Heyning and Perrin 1994). According to the NMFS (2010h), a recent minimum population estimate for this species was about 17,127. The northern limit for this stock is the waters off California and animals likely move between U.S. and Mexican waters.

Long-Beaked Common Dolphin

Source:http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/commondolphin_longbeaked.htm

Short-beaked common dolphins (*Delphinus delphis*) are the most abundant cetacean off California and range from the coast to 300 nm (555 km) offshore. The most recent minimum estimates indicate the California-Washington population of this species is approximately 343,990 individuals (NMFS 2010i). Neither of these dolphin species is

listed under the ESA. California common dolphins are very gregarious and are frequently encountered in herds of 1,000 or more. Because populations tend to vary with water temperature, no long-term population trends have been determined at this time (NMFS 2010i).

Short-Beaked Common Dolphin

Source: http://en.wikipedia.org/wiki/Short-beaked_common_dolphin

Common dolphins were observed regularly from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (PG&E 2011b). According to Calambokidis et al. (2008), common dolphins have frequently been documented entering the safety (exclusion) zones of seismic surveys.

Dall's Porpoise (MMPA Protected)

Dall's porpoises (*Phocoenoides dalli*) are commonly seen off the western coast of the U.S. in shelf, slope, and offshore waters. Though the southern end of this population's range is not well-documented, they are commonly seen off Southern California in winter, and they probably range into Mexican waters off northern Baja California during cold-water periods (NMFS 2010j). The distribution of this species appears highly variable from year-to-year and likely depends on oceanographic conditions. Dall's porpoises feed mostly on Pacific hake (*Merluccius productus*), northern anchovy, Pacific saury (*Cololabis saira*), juvenile rockfish, and cephalopods (NCCOS 2007, as cited in PG&E 2011b).

Dall's Porpoise

Source:http://marinebio.org/species.asp?id=363

The population trend for this species has not yet been determined. The minimum population estimate based on the 2005 to 2008 abundance estimates for the outer coast of California, Oregon, and Washington is 32,106 porpoises (NMFS 2010j). Ten Dall's porpoises were observed through the winter during geophysical surveys conducted by PG&E from October 24 to December 17, 2010 and from January 5 to February 5, 2011.

Harbor Porpoise (MMPA Protected)

Harbor porpoise (*Phocoena phocoena*) are found in coastal and inland waters from Point Conception, California to Alaska and across to Kamchatka and Japan (Gaskin

1984, as cited in NMFS 2009c). The harbor porpoise occurs year-round off of central California, mostly in the coastal ocean and occasionally in bays, harbors, and estuaries (PG&E 2011b). As reported in the 2009 Stock Assessment Report (NMFS 2009c), analyses of genetic samples from harbor porpoises ranging from Monterey Bay, California to Vancouver Island, British Columbia indicate that there is small-scale subdivision within the U.S. portion of this range. Carretta et al. (2001a, as cited in NMFS 2009c) suggested there are six stocks in California, Oregon, and Washington, including a Morro Bay stock.

The minimum population estimate for the harbor porpoise Morro Bay stock (occurring between Cambria and Point Conception) is approximately 1,478 and the population appears to be increasing (NMFS 2009c). Harbor porpoises were observed regularly while transiting to the Project area from late summer through winter of 2010 (PG&E 2011b). Harbor porpoise are considered to have high sensitivity to seismic exploration sound (Lucke et al. 2009).

Harbor Porpoise

Source:http://www.cms.int/reports/small_cetaceans/data/P_phocoena/p_phocoena.htm

Pacific Coast White-sided Dolphin (MMPA Protected)

Pacific Coast White-sided Dolphin

Source:http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/whitesideddolphin_pacific.htm

Pacific coast white-sided dolphins (*Lagenorhynchus obliquidens*) primarily range along the coasts of California, Oregon, and Washington. This species frequents deep water foraging areas and is often seen in the high seas, but may move into the coastal region nearshore in search of prey. As water temperatures increase in late spring and summer, Pacific coast white-sided dolphins tend to move northward to Oregon and Washington while during cold water months the species can be found primarily off California (Leatherwood et al. 1984; Forney et al. 2000, as cited in NMFS 2010k). This species is often sighted together with Risso's and Northern right whale dolphins. The population of Pacific coast white-sided dolphins is not showing any long-term trend in terms of abundance, but has a current minimum estimate of 21,406 off California, Oregon, and Washington (NMFS 2010k).

Striped Dolphin (MMPA Protected)

Striped dolphins (*Stenella coeruleoalba*) can be found in warm, tropical waters throughout the world. Off the coast of California, striped dolphins have been seen during shipboard surveys between 100 and 300 nm (185 and 556 km) offshore. Because these surveys were only conducted during the summer and fall, there are no data on seasonal distribution of this species off California. The minimum estimate for the California/Oregon/Washington stock is approximately 10,908. There is currently no information on population trends for this stock (NMFS 2011f).

Baird's Beaked Whale (MMPA Protected)

Baird's beaked whales (*Berardius bairdii*) can be found in deep waters along the continental slope off California's coast typically between late spring and early fall. Between November and April, this species is presumed to spend more time in deeper waters farther offshore.

The minimum population estimate for Baird's beaked whales in California, Oregon, and Washington was 615 based on data from 2005 to 2008 (NMFS 2011g). Because this species is rarely sighted, its seasonal distribution is difficult to determine and population trends are lacking for the western coast of the U.S. (NMFS 2011g). Baird's beaked whales may be capable of diving up to 9,840 feet (3,000 m) and typically feed between 2,500 and 4,000 feet (800 and 1,200 m) below the surface.

Baird's Beaked Whale

Source:http://www.cms.int/reports/small_cetaceans/data/b_bairdii/b_bairdii.htm

This species prefers pelagic fish (e.g., mackerel, sardines, and saury), crustaceans, and sea cucumbers, as well as squid and octopus (NMFS 2011h).

Cuvier's Beaked Whale (MMPA Protected)

Cuvier's beaked whales (*Ziphius cavirostris*) are distributed in deep waters throughout the world and the California, Oregon, and Washington stock is found along the western coast of the U.S. more commonly than other beaked whale species. Despite this, sightings are rare and population trends are not available.

Cuvier's Beaked Whale

Source:http://www.cms.int/reports/small_cetaceans/data/Z_cavirostris/z_cavirostris.htm

The minimum population estimate reported in the 2011 Stock Assessment Report (California/Oregon/Washington stock) is 1,298 whales (NMFS 2011i). Similar to other beaked whales, Cuvier's beaked whales are deep divers, capable of diving up to 3,300 feet (1,000 m) to feed on squid and octopus. Beaked whale species are thought to be sensitive to anthropogenic noise, and are subject to entanglement in fishing gear and ship strikes (NMFS 2011j).

Risso's Dolphin (MMPA Protected)

Risso's dolphins (*Grampus griseus*) are distributed worldwide in warm-temperate and tropical waters. This species is commonly seen along the continental shelf in the Southern California Bight, and offshore and along the coast in California, Oregon, and Washington. Risso's dolphins found off California during the colder water months move northward as water temperatures increase in late spring and summer (Green et al. 1992, as cited in NMFS 2011k).

Based on mean abundance estimates from 2005 to 2008, the current minimum population estimate of Risso's dolphins indicates that at least 4,913 individuals are known to occur off California, Oregon, and Washington and no long-term population trends have been determined at this time (NMFS 2011k). Risso's dolphins can be observed year-round within the Project area. Risso's dolphins were observed regularly from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (PG&E 2011b).

Risso's Dolphins

Source:http://www.cms.int/reports/small_cetaceans/data/g_griseus/g_griseus.htm

Bottlenose Dolphin (MMPA Protected)

Bottlenose Dolphins

Source:http://www.cms.int/reports/small_cetaceans/data/t_truncatus/t_truncatus.htm

Similar to other dolphins found within the Project area, bottlenose dolphins (*Tursiops truncatus*) are distributed throughout the world in tropical and warm-temperate waters. In California, as in other regions, the species is divided into two separate populations, coastal and offshore (Walker 1981; Ross and Cockcroft 1990; Van Waerebeek et al. 1990, as cited in NMFS 2008). Coastal bottlenose dolphins in California are found within about 0.6 miles (1 km) of shore (Hansen 1990;

Carretta et al. 1998; Defran and Weller 1999, as cited in NMFS 2008) near bays, inlets, and river mouths.

The California coastal population is estimated at 290 and appears to form small resident groups that range along the coastline, especially off Orange and San Diego Counties (NMFS 2008). Bottlenose dolphins found offshore have been at distances greater than a few km from the mainland and throughout the Southern California Bight. Offshore bottlenose dolphins are believed to have a more-or-less continuous distribution off the coast of California (Mangels and Gerrodette 1994, as cited in PG&E 2011b). According to NCCOS (2007), groups of 13 or more animals have been recorded in the Project area. The current minimal population of bottlenose dolphins is estimated at a minimum population size of 684 individuals off California, Oregon, and Washington. Data on population trends for offshore bottlenose dolphins are not currently available (NMFS 2011l).

Northern Right Whale Dolphin (MMPA Protected)

Northern right whale dolphins (*Lissodelphis borealis*) are endemic to temperate waters of the North Pacific, where they range from the Mexican border to British Columbia (Leatherwood and Walker 1979; Leatherwood et al. 1982, as cited in PG&E 2011b). They are primarily found over the shelf and slope in U.S. coastal waters and are known to make seasonal north-south movements (Forney et al. 2000). Similar to many other species found in this region, northern right whale dolphins are found primarily off California during colder-water months and shift northward into Oregon and Washington as water temperatures increase in late spring and summer (NMFS 2011m), though some individuals may be found off the California coast in cold months.

The current minimum population estimate is approximately 6,019 along the coasts of California, Oregon, and Washington. There is currently no evidence for a population trend for this stock (NMFS 2011m). Ten northern right whale dolphins were observed from late summer through winter of 2010 during marine mammal monitoring events within Project area waters (PG&E 2011b).

Northern Right Whale Dolphin

Source:http://www.cms.int/reports/small_cetaceans/data/L_borealis/L_borealis.htm

Killer Whale (ESA Endangered; MMPA Depleted [Southern Resident Stock only])

Killer whales (*Orcinus orca*) are found throughout the North Pacific, including along the outer coasts of California, Oregon, and Washington (Green et al. 1992; Barlow 1995; Barlow 1997; Forney et al. 1995, as cited in NMFS 2010n). Data on association patterns, movements, acoustics, potential fishery interactions, and genetics suggest that

there are eight killer whale stocks recognized along the Pacific coast within the Exclusive Economic Zone of the U.S. Genetic evidence supports that there are differences between populations characterizing them into three distinct groups, including "resident," "offshore," and "transient" killer whales (NMFS 2010n). The stocks occurring off California's coast include (1) the Southern Resident stock, (2) the West Coast Transient stock, and (3) the Offshore stock. The West Coast Transient stock is the most frequently sighted type of killer whale off central California and is also referred to as the Northeast Pacific Transient stock. Transient killer whales feed on marine mammals, travel in small groups, often over long ranges, and are usually vocally quiet (NCCOS 2007, as cited in PG&E 2011b). Combining whale counts from different regions results in a minimum population estimate for the West Coast Transient killer whale stock of approximately 354 whales (NMFS 2010n). The West Coast Transient stock grew rapidly from the mid-1970s through mid-1990s due to high birth rates, high survival, and immigration of animals into the nearshore area. Since the mid-1990s, population growth slowed and stayed slow in recent years (Department of Fisheries and Oceans 2009, as cited in NMFS 2010n). The West Coast Transient killer whale stock is not designated as depleted under the MMPA or listed under the ESA (NMFS 2010l).

Killer Whales

Source:http://www.cms.int/reports/small_cetaceans/data/o_orca/o_orca.htm

Offshore killer whales have been identified off the coasts of California, Oregon, and rarely, in Southeast Alaska (NMFS 2011n). They apparently do not mix with the transient and resident killer whale stocks found in these regions (NMFS 2011n). The total number of known offshore killer whales along the U.S. West coast, Canada and Alaska is 211 animals, with approximately 162 whales estimated to be in U.S. waters off California, Oregon and Washington (NMFS 2011n). Offshore killer whales are not listed under the Endangered Species Act or as depleted under the MMPA.

Some pods from the Eastern North Pacific Southern Resident stock of killer whales have been sighted as far south as Monterey Bay and central California in recent years (NMFS 2011o). The minimum population estimate for the Eastern North Pacific Southern Resident stock of killer whales is 86. On November 15, 2005 NMFS listed Southern Resident killer whales as endangered under the ESA and consequently, this stock is listed as a strategic stock under the MMPA. During recent surveys within the Project area, killer whales were commonly observed (PG&E 2011b; Tenera 2007, 2008 as cited in PG&E 2011b). Two killer whales were observed within the Project area during the geophysical survey conducted by PG&E from October 24 to December 17, 2010 and January 5 to February 5, 2011 (PG&E 2011b).

Sperm Whale (ESA Endangered; MMPA Depleted)

The sperm whale (*Physeter macrocephalus*) was listed as an endangered species under the ESCA due to historically intensive commercial whaling, and retains its endangered status today. The sperm whale is the largest of the toothed whales and is found predominately in temperate to tropical waters in both hemispheres. Off California, sperm whales are present in offshore waters year-round (NMFS 2011p), with peak abundance from April to mid-June and again from late August through November (NMFS 2011p). Sperm whales are primarily pelagic species and are generally found in waters with depths of greater than 3,300 feet (1,000 m) (NMFS 2011p), although their distribution does suggest a preference for continental shelf margins and seamounts, areas of upwelling and high productivity. The majority of sightings by Dohl et al. (1983, as cited in NMFS 2011p) in their three-year study off central and northern California were in waters deeper than 5,900 feet (1,800 m), but near the continental shelf edge.

The most recent minimum estimates indicate that at least 751 individuals are known to occur off California, Oregon, and Washington (NMFS 2011p). The eastern North Pacific population of sperm whales is expected to have increased since whaling stopped in 1980, it is difficult to determine total abundance for this stock given the variability of estimates off California during some years. To date, no statistical analysis has been conducted to determine trends (NMFS 2011p).

Sperm Whale

Source:http://www.cms.int/reports/small_cetaceans/data/P_macrocephalus/P_macrocephalus.htm

Pinnipeds (Seals and Sea lions)

Six of the 36 species of pinnipeds known worldwide occur off the central California coast. Four are eared seals (family Otariidae) and two are earless seals (family Phocidae). The species most likely to be encountered within the vicinity of the Project area include the California sea lion, northern fur seal, northern elephant seal, and the Pacific harbor seal (Bonnell et al. 1987, as cited in PG&E 2011b).

Otariidae

The species of Otariidae (eared seals) that may occur in central California waters include: northern fur seals (*Callorhinus ursinus*), Guadalupe fur seals (*Arctocephalus townsendi*), Steller sea lions (*Eumetopias jubatus*), and California sea lions (*Zalophus californianus*), with the most common species within the Project area being the California sea lion.

California Sea Lion (MMPA Protected)

California sea lions are the most abundant pinnipeds in California, representing 50 to 93 percent of all pinnipeds on land and about 95 percent of all sightings at sea (Bonnell et al. 1981; Bonnell and Ford 1987, as cited in PG&E 2011b). This species ranges from Baja, Mexico to British Columbia. The breeding time period and rookery occupancy is mid-May to late July (PG&E 2011b). In central California, a small number of pups are born on Año Nuevo Island, Southeast Farallon Island, and occasionally at a few other locations; otherwise, the central California population is composed of non-breeders.

The minimum population estimate for the California sea lion stock is 153,337 (NMFS 2011t). This number is believed to be increasing despite recent drops in pups due to El Niño events occurring in the late 1990s (NMFS 2007a). California sea lions were observed regularly from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (PG&E 2011b). California sea lions are not listed as threatened or endangered under the ESA.

California Sea Lions

Source:http://en.wikipedia.org/wiki/California_sea_lion

Northern Fur Seal (MMPA Protected)

The northern fur seal is the most abundant otarid in the Northern Hemisphere. Most of the population is associated with rookery islands in the Bering Sea and the Sea of Okhotsk. However, of the seals in U.S. waters, approximately one percent of the population is found on Bogoslof Island in the southern Bering Sea and on San Miguel Island off southern California (NMFS 2011r). Different requirements during the annual reproductive season mean that males and females are on shore at different periods, overlapping some of that time. Adult males usually occur on shore during the 4-month period from May to August, though some may be present until November, well after giving up their territories. Adult females are found ashore for as long as six months (June through November) (NMFS 2011r). Adult females and juveniles migrate to the central California area (and Oregon and Washington) from rookeries on San Miguel Island in the Southern California Bight, and from the Pribilof Islands in the Bering Sea (NCCOS 2007, as

Northern Fur Seal

Source:http://en.wikipedia.org/wiki/Northern_fur_seal

cited in PG&E 2011b). There is considerable interchange of individuals among rookeries. During winter migration, female northern fur seals from the Pribilof Islands travel south and arrive off California beginning in February and remain until about August before returning to breeding grounds (PG&E 2011b). The most recent minimum population estimates for the San Miguel Island stock indicate that at least 5,395 individuals are known to occur. No long-term population trends have been determined at this time (NMFS 2011r). The San Miguel Island northern fur seal stock is not considered to be depleted under the MMPA or listed as threatened or endangered under the ESA.

Steller Sea Lion (ESA Threatened)

The eastern stock of Steller sea lions (*Eumetopias jubatus*) is listed as threatened species under the ESA. The Steller sea lion ranges along the North Pacific rim, from northern Japan, the Aleutian Islands, Gulf of Alaska, and south to Año Nuevo Island, California (the southernmost rookery). A northward shift in the overall breeding distribution has occurred, with a contraction of the range in southern California and new rookeries established in southeastern Alaska (NMFS 2010m).

Steller Sea Lions

Source:http://en.wikipedia.org/wiki/Steller_sea_lion

Three haul-out sites have been documented within the Project area (PG&E 2011b). The minimum population estimate for the eastern stock of Steller sea lions indicates that at least 2,479 animals were observed in California. This population is stable or slightly increasing (NMFS 2010m).

Guadalupe Fur Seal (ESA and CESA Threatened)

The Guadalupe fur seal is a Federal- and State-threatened species, and a fully protected species under California Fish and Game Code Section 4700, subdivision (b)(4). Guadalupe fur seals pup and breed at Isla Guadalupe, Mexico; however, in 1997, a second rookery was at Isla Benito del Este in Baja California. Though individuals have been sighted or stranded as far north as Blind Beach, California, they are typically found farther south. While once abundant, these seals almost became extinct due to extensive commercial

Guadalupe Fur Seal

Source:http://marinebio.org/species.asp?id=301

harvest in the 19th century. The population is now listed as a threatened species under both the State and Federal ESAs and is considered a single stock (Mexico stock) from one breeding colony. The minimum population estimate for this species is 3,028 and is likely increasing (NMFS 2000).

During breeding season, Guadalupe fur seals are found in coastal rocky habitats and caves though little is known about their whereabouts during the non-breeding season (September to May). Some individuals travel north to the Channel Islands in late summer (NSF and USGS 2011) and may occur in small numbers in Central California, but no sightings were recorded in the review by NCCOS (2007).

Phocidae

Two species of Phocidae (earless seals) that are known to occur within the central California coast include the northern elephant seal (*Mirounga angustirostris*) and Pacific harbor seal (*Phoca vitulina richardsi*). These species are listed as Protected under the MMPA, and the northern elephant seal is designated as a fully protected species under section 4700, subdivision (b)(3) of the California Fish and Game Code.

Northern Elephant Seal (MMPA Protected)

Northern elephant seals breed along the coast from Baja California north to Point Reyes. Northern elephant seals typically haul out on land only to breed and molt and then disperse widely at sea. The breeding period is generally December through March and molting occurs April through August—females and juveniles molt in April to May, subadult males molt in May to June, adult males molt in July to August, and yearlings molt in the fall. The northern elephant seal is present year-round off of central California; however, because they spend very little time at the surface and forage mostly offshore, at-sea sightings are rare (NCCOS 2007, as cited in PG&E 2011b).

Northern Elephant Seals

Source:http://en.wikipedia.org/wiki/Northern_elephant_seal

The most recent population estimates for the California breeding stock of Northern elephant seals indicate that at least 74,913 individuals are known to occur in California and the stock appears to be increasing (NMFS 2007b). No haul-out or rookeries have been documented within the Project area. Northern elephant seals are not listed as threatened or endangered under the ESA or as depleted under the MMPA.

Pacific Harbor Seal (MMPA Protected)

Pacific harbor seals range from Mexico to the Aleutian Islands (NMFS 2011s). Approximately 400 to 600 harbor seal haul-out sites are widely distributed in California along the mainland and on offshore islands, including intertidal sandbars, rocky shores, and beaches (Hanan 1996; Lowry et al. 2005, as cited in NMFS 2005). Unlike most pinnipeds occurring off California, Pacific harbor seal maintain haul-out sites on the mainland on which they pup and breed (Rambo 1978; Bowland 1978, as cited in PG&E 2011b). Haul-outs may be occupied at any time of year for resting. Pupping generally occurs from March to June and molting occurs from May to July (PG&E 2011b).

Harbor Seal

Source:http://en.wikipedia.org/wiki/Harbor_seal

Minimum population estimates of the California stock from 2005 indicated there were 26,667 seals (NMFS 2005a), though no new estimates are currently available. After increases in the 1990s, this population is believed to be stable and possibly reaching its carrying capacity (NMFS 2011q). Pacific harbor seals were observed regularly from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (PG&E 2011b).

Fissipeds (Sea Otters) (ESA Threatened; MMPA Depleted)

The southern sea otter (*Enhydra lutris nereis*) is the only fissiped species known to occur within the central California coast. The southern sea otter is listed as a threatened species under the ESA, depleted under the MMPA, and is designated as a fully protected species under section 4700, subdivision (b)(8), of the California Fish and Game Code. These animals occupy nearshore waters along the mainland coastline of California from San Mateo County to Santa Barbara County (USFWS 2008). Historically, the range of sea otters extended from the northern islands of the Japanese Archipelago northeast along Alaska and southward along North America to Baja California (Dailey et al. 1993, as cited in PG&E 2011b). In the 1700s and 1800s, southern sea otters were nearly extirpated by the fur trade. The current range extends from about Half Moon Bay in the north to Santa Barbara in the south. A small, satellite population of approximately 20 to 40 animals also occurs at San Nicolas Island, the result of a translocation effort in the late 1980s (PG&E 2011b). This species prefers rocky shoreline with water depth of less than 50 feet (15 m), which support kelp beds where they feed on benthic macroinvertebrates including clams, crabs, abalone, sea urchins, and sea stars.

Mating and pupping of southern sea otters takes place year round, but a birth peak extending over several months occurs in the spring, and a secondary birth peak occurs in the fall (Siniff and Ralls 1991; Riedman et al. 1994, as cited in USFWS 2008). Male sea otters typically aggregate at the northern and southern limits of the range in winter and early spring, when some males that have maintained breeding territories in the predominantly female center of the range abandon their territories and join other males at its ends (Jameson 1989; Ralls et al. 1996, as cited in USFWS 2008).

Southern Sea Otter

Source:http://www.montereybayaquarium.org/animals/AnimalDetails.aspx?enc=SDMMaV57mBkF08cP1aGO1Q==

Recent minimum population estimates for southern sea otters in California indicate that at least 2,711 individuals are known to occur and the 3-year average of the total count represents a 3.6 percent drop from 2009. The declines over the past 2 years seem to indicate the population may be in a period of decline (USGS 2010). Seasonally within the Project area, an increase in population could be seen during the period when most breeding occurs (June to November) (PG&E 2011b). According to USGS (2010), the highest density within Project area is around Point Buchon. Southern sea otters were observed regularly from late summer through winter of 2010 during marine mammal monitoring events within or near Project area waters (PG&E 2011b).

Invasive Species

In 2008, CDFG published a report summarizing a large-scale field survey of California coastal waters for invasive species (CDFG 2008). The report indicates that all major harbor areas in California have a substantial number of invasive species, including Morro Bay near the Project area. According to the report, each major commercial harbor area of the state has between 40 and 190 non-native aquatic species and another 15 to 138 species of unknown origin (cryptogenic) that are possibly introduced (CDFG 2008). Some of the most problematic aquatic invasive species (AIS) that have become established in California include the European green crab, the Chinese mitten crab, the Asian overbite clam (*Corbula amurensis*), and a plethora of aquatic plants with origins as far away as Brazil and Japan (CSLC 2010).

The majority of the species introduced to California appear to be native to the northwest Atlantic, the northwest Pacific, and the northeast Atlantic. Many of these species are believed to have been introduced through their accumulation on hard surfaces, such as the bottom of a vessel, often referred to as fouling. It is difficult to determine whether non-native (invasive) species are introduced by recreational boats or commercial ships. Ballast water is also a major pathway for introduction of invasive species. Ballast water

discharge from ships was the second-largest category of potential pathways, indicating that shipping plays a substantial role in dispersal of species (CDFG 2008).

Introduced species may out-compete or alter local habitats to such an extent that they make it impossible for native species to survive due to predation, competition for resources, or parasites and disease. According to Wilcove et al. (1998, as reported by CDFG 2008), half of all threatened or endangered species are imperiled by introduced species, making introduced species second only to habitat loss as the greatest threat to endangered species.

In 2004, the USCG established regulations for a national mandatory Ballast Water Management program for all vessels equipped with ballast water tanks that enter or operate within U.S. waters. This statute requires all ships to: (1) prepare Ship Invasive Species Management Plans outlining procedures to prevent introductions of invasive organisms; (2) report ballast operations, treatment, and management practices; and (3) carry out Best Management Practices to reduce the movement of species by ships. Beginning in 2012, all vessels entering a U.S. port are required to conduct ballast water treatment so that ballast water discharged contains less than one living organism that is larger than 50 micrometers in dimension per 10 cubic meters of water and less than one living organism that is smaller than 50 micrometers per 10 milliliters of water.

In addition to national regulations, in 2008, the California AIS Management Plan (AIS Plan) was signed into law, which provides a framework for agency coordination and identifies actions to minimize the harmful effects of AIS in California. One of the top priorities identified in the AIS Plan is to conduct statewide assessments of the risks from specific vectors for introductions of nonindigenous aquatic species. Another high priority identified by the AIS Plan is to support early detection and rapid response actions, partly by coordinating various aquatic invasive monitoring programs throughout the state (CDFG 2008).

Of particular note is Caulerpa *(Caulerpa taxifolia),* a highly invasive green alga that is known to have caused ecological devastation in the Mediterranean by supplanting native seaweeds, sea grasses, reefs, and other communities. It is also reported to have had significant adverse effects in the Mediterranean on tourism and recreational boating, recreational diving, and commercial fishing (by altering fish distribution and impeding net fisheries). NMFS has determined that Caulerpa poses a substantial threat to marine ecosystems in California and the food web that is critical to the survival of numerous native marine species, including those of commercial and recreational importance. In response to this threat, in September 2001, Assembly Bill 1334 was enacted by the State of California banning the transport, sale, and possession of nine potentially invasive species of *Caulerpa*, including *C. taxifolia*. The other species include *C. mexicana, C. racemosa, C. cupressoides, C. sertularioides, C. ashmeadii, C.*

floridana, C. scalpelliformis, and C.verticillata. In order to detect existing infestations as well as avoid the spread of these invasive species, the NMFS and the CDFG jointly developed a Caulerpa Control Protocol (NMFS 2008) for California nearshore coastal and enclosed bays, estuaries, and harbors from Morro Bay to the U.S./Mexican border. This protocol requires that project sites in southern California bays and harbors be surveyed for Caulerpa before conducting activities involving seafloor disturbance, and establishes certification, survey, and reporting guidelines to be followed in that area when surveying for the presence of Caulerpa. The Project area is at the northernmost boundary of the region to which the Caulerpa Control Protocol (NMFS 2008) applies, and Caulerpa is not typically expected to be present in the Project area. Regardless, this protocol applies to portions of the offshore Project area.

4.4.2 Regulatory Setting

The statutes, regulations, plans, and policies relevant to the proposed Project that address marine biology resource issues are summarized in Table 4.4-8. For additional detail on these regulations, please refer to Table 4.0-1.

Table 4.4-8 Regulatory Requirements Relevant to Marine Biology Resource Impacts

Regulation	Relevant Requirements
Federal	
Endangered Species Act	Under the ESA, the Secretary of the Interior and the Secretary of Commerce jointly have the authority to list a species as threatened or endangered. The USFWS has jurisdiction over plants, wildlife, and resident fish, while the NMFS has jurisdiction over anadromous fish and marine fish and mammals under the ESA. Pursuant to the requirements of the ESA, a Federal agency reviewing a proposed project within its jurisdiction must determine whether any Federal-listed threatened or endangered species may be present in the project site and determine whether the proposed project will have a potentially significant impact on such species. In addition, the agency is required to determine whether the project is likely to jeopardize the continued existence of any species proposed to be listed under the ESA or result in the destruction or adverse modification of critical habitat proposed to be designated for such species.
Marine Mammal Protection Act	NMFS may issue a marine mammal take permit under section 104 of the MMPA if the activities are consistent with the purposes of the MMPA and applicable regulations under Code of Federal Regulations (CFR) title 50, part 216. NMFS must also find that the manner of taking is “humane” as defined in the MMPA. If lethal taking of a marine mammal is requested, the applicant must demonstrate that a using a non-lethal method is not feasible.

Regulation	Relevant Requirements
Magnuson-Stevens Fishery Conservation and Management Act	The MSA requires "the identification of EFH for federally managed species and the implementation of measures to conserve and enhance this habitat." Any project requiring Federal authorization, such as a USACE permit, is required to complete and submit an EFH Assessment with the application and either show that no significant impacts to the essential habitat of managed species are expected or identify mitigations to reduce those impacts.
Coastal Zone Management Act	Coastal states with an approved Coastal Zone Management Plan, which defines permissible land and water use within the state's coastal zone, can review Federal actions, licenses, or permits for "Federal consistency." California's coastal zone management program, created in response to the Coastal Zone Management Ac, is the California Coastal Act. Federal consistency is the requirement that those Federal permits and licenses likely to affect any land/water use or natural resources of the coastal zone be consistent with the state program's enforceable policies (see Table 4.0-2).
Clean Water Act	*National Estuary Program.* The Morro Bay National Estuary Program is one of 28 programs in the country born out of national program. The United States Environmental Protection Agency provides funding and technical support to each National Estuary Program to safeguard and improve the health of Morro Bay's coastal waters.
National Marine Sanctuary Act	The National Marine Sanctuary Program, operating under the National Marine Sanctuary Act and administered by National Oceanic and Atmospheric Administration's (NOAA's) National Ocean Service has the authority to issue special use permits for research activities that would occur within a National Marine Sanctuary. Obtaining special use permits is the responsibility of individual researchers.
Executive Order 13158 Marine Protected Areas (MPAs)	Federal agencies must identify actions that affect natural or cultural resources that are within an MPA. It further requires Federal agencies, in taking such actions, to avoid harm to the natural and cultural resources that are protected by an MPA.
Executive Order 13112 Invasive Species	Federal agencies must use authorities to prevent introduction of invasive species, respond to and control invasions in a cost-effective and environmentally sound manner, and provide for restoration of native species and habitat conditions in ecosystems that have been invaded.
Ballast Water Management Act	This statute requires all ships to: (1) prepare Ship Invasive Species Management Plans outlining procedures to prevent introductions of invasive organisms; (2) report ballast operations, treatment and management practices; and (3) carry out Best Management Practices to reduce the movement of species by ships.

Regulation	Relevant Requirements
State	
California Endangered Species Act (CESA)	Section 2080 of the Fish and Game Code prohibits "take" of any species that the commission determines to be an endangered species or a threatened species. Take is defined in Section 86 of the Fish and Game Code as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." CESA allows for take incidental to otherwise lawful development projects. CESA emphasizes early consultation to avoid potential impacts to rare, endangered, and threatened species and to develop appropriate mitigation planning to offset project caused losses of listed species populations and their essential habitats. In some instances, State laws and regulations do not allow for the take of native species. Four sections of the Fish and Game Code list 37 fully protected species (Fish and Game Code Sections 3511, 4700, 5050, and 5515). Each of these statutes: (1) prohibits take or possession "at any time" of the species listed in the statute, with few exceptions, (2) states that "no provision of this code or any other law shall be construed to authorize the issuance of permits or licenses to "take" the species, and (3) states that no previously issued permits or licenses for take of the species "shall have any force or effect" for authorizing take or possession.
California Marine Life Protection Act (MLPA)	The California MLPA mandates that the CDFG develop a plan to establish and manage an improved network of MPAs to, among other things, protect marine life and habitats and preserve ecosystem integrity. The MLPA establishes clear policy guidance and a scientifically sound planning process for the siting and design of MPAs such as marine reserves, marine parks, and marine conservation areas. Cambria-White Rock MPA/State Marine Conservation Area and the western portion of the Point Buchon MPA are within the Project area.
California Aquatic Invasive Species Management Plan	Provides a framework for agency coordination and identifies actions to minimize the harmful effects of aquatic invasive species in California.

4.4.3 Significance Criteria

An impact on marine biological resources would be considered significant and would require additional mitigation if the Project would cause any of the following to occur:

- A substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFG, USFWS, or NMFS;
- The “take” of special status species in accordance with NMFS policies for marine mammals and/or result in underwater or in-air noise levels that were equal to or exceeded NMFS guidelines for Level A or B harassment of marine mammals (i.e., peak in-water levels generally at or above 160 decibels [dB] re 1

micropascal [μPa] root mean square [rms], or in-air levels generally at or above 90 dBA) and/or in-water noise levels that exceed 190 dB re 1μPa rms for sea turtles;

- The "take," as defined in section 86 of the California Fish and Game Code, of species listed under the California ESA or designated as "fully protected" pursuant to the California Fish and Game Code.
- A substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulation, or by the California Coastal Commission, CDFG, USFWS, or NMFS;
- A substantial interference with the movement of any native resident or migratory fish or wildlife species, or with established native resident or migratory wildlife corridors, or impede the use of a native wildlife nursery site;
- A conflict with local policies or ordinances protecting biological resources;
- A conflict with the provisions of an adopted species Recovery Plan, Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan;
- A substantial reduction in the habitat of a fish or wildlife species;
- The population of a fish or wildlife population drops below self-sustaining levels; or
- The introduction of non-native, invasive species.

4.4.4 Assessment Methodology

For the purposes of this EIR, potential impacts to marine biological resources were evaluated based on available literature and publicly available documents that provided information on species status, distribution, habitat and particular sensitivities to stressors (i.e., noise) that are summarized in Subsection 4.4.5 – Impact Analysis and Mitigation Measures. Impacts that are considered substantial are considered to be those that would diminish, or result in the loss of, an important biological resource, or those that would conflict with local, state, or Federal resource conservation plans, goals, or regulations. Impacts are sometimes locally important, but not significant according to CEQA, because although the local impacts would result in an adverse alteration of existing conditions, they would not substantially diminish, or result in the permanent loss of, an important resource on a population-wide or region-wide basis.

For purposes of this EIR, the following components were considered of principle importance to the analysis and to determining the significance of an effect in relation to the criteria outlined above:

- Context
- Species seasonal occurrence and density
- Listed status
- Habitat use (for example, migration or breeding)
- Sensitivity to stressors
- Intensity of Project activity (spatial extent, magnitude such as substantial or not substantial, and duration such as short-term or long-term); and
- Likelihood of an event or effect.

Potential Project impacts to marine wildlife may include direct effects such as auditory injury, vessel collision, oil effects and entanglement, as well as indirect effects such as disturbance, displacement, and secondary prey effects. The methodologies used to assess noise impacts are described in more detail below.

Methodology for Noise Impact Analysis for Invertebrates and Fish

Potential effects on fish and invertebrates in the Project area, including the close vicinity of the air gun sound discharges, were evaluated based on information available in the literature, habitats and species known to exist in the Project area, and expected noise levels as estimated by noise modeling, which are presented in Appendix I – Underwater Noise Assessment. A summary of findings from the literature is incorporated into the impact discussions.

Methodology for Noise Impact Analysis for Marine Mammals

The evaluation of potential noise impacts on marine mammals presented herein is based on detailed analyses performed for this EIR using species-specific criteria and noise modeling results. The methodology consisted of the following critical steps:

- Identifying species of concern, and determining which species would require a full “take” analysis based on vulnerability and expected presence during the survey. Sixteen species were selected for full take analysis.
- Estimating animal densities of the selected species.

“Take” and “Harassment” Under the MMPA

Take

As defined under the MMPA, to "harass, hunt, capture, kill or collect, or attempt to harass, hunt, capture, kill or collect."

Harassment

Harassment is defined under the MMPA as any act of pursuit, torment, or annoyance that:

- ***(Level A Harassment)*** has the potential to injure a marine mammal or marine mammal stock in the wild; or,
- ***(Level B Harassment)*** has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.

- Establishing criteria for injury and disturbance effects.
- Establishing criteria for assessing the severity of the impact.
- Applying noise modeling results to determine potential impacts and severity of the noise generated by the Project.
- Applying Applicant Proposed Measures (APMs) and Mitigation Measures (MMs) to reduce or avoid significant effects.
- Determining level of significance using CEQA criteria, after application of APMs and MMs.

Each of these steps is described in more detail below. The noise impact analysis for marine mammals is documented in the Marine Mammal Technical Report, which is provided in Appendix H; the underwater noise modeling approach and results are documented in the Underwater Noise Assessment report provided in Appendix I.

Species Screening

The 16 species that were included in the quantitative take analysis are listed below in Table 4.4-9.

Table 4.4-9 Mammal Species Identified for Quantitative Take Analysis

Species[1]	Rationale for Inclusion in Take Analysis
Fin whale	Fin whales have the highest density of the ESA-listed strategic mysticete species within the Project area. This species is seasonally present in the area, extending from the continental slope to offshore; lower species density is assumed during winter months.
Humpback whale	Humpback whales are an ESA-listed mysticete known to frequent the Project area at relatively high densities in some years. Humpback whales are known to migrate southwards through the Project area in late fall (September and October); however, densities decrease substantially by mid-November. The humpback whale migration route uses more of the inshore areas than the route of blue whales.
Blue whale	Blue whales are listed as endangered under the ESA and are known to frequent the Project area at relatively high densities in some years. Blue whales are known to migrate southwards through the Project area in late fall (September and October); however, densities typically decrease by mid-November. There have been observations of high numbers of whales during fall months, notably from 2000 through 2003.
Minke whale	Minke whales are considered uncommon in the area, but may occasionally be present. Minke whales are found primarily over the continental shelf. There may be some resident whales in the area, but not easily sighted. There are no direct measurements of responses of minke whales to seismic noise, but based on responses in gray and humpback whales, localized and temporary avoidance behavior would be expected.
Short-beaked common dolphin	Short-beaked common dolphins are the most abundant cetacean in the Project area and occur from the coast seaward to at least 311 miles (500 km) offshore (with majority occurring seaward of 656 feet [200 m]). Recent population estimates have shown an increase in abundance in California, with large seasonal changes in distribution documented. This species occurs in large groups (in the hundreds or even thousands), and is likely present in higher numbers in September and October than later in the season.
Long-beaked common dolphin	Long-beaked common dolphins occur mostly off southern California and Baja California, generally within about 56 miles (90 km) of the coast. They occur in large groups (in the hundreds), including sightings within the Project area. As with short-beaked common dolphins, there have been multiple confirmed occurrences of common dolphins entering Exclusion Zones of seismic surveys.
Small-beaked whale species	Due to the rarity of sightings, species of beaked whales in the Project area have been grouped for this assessment. Baird's beaked whales are distributed along continental slopes and throughout deep waters of the North Pacific, while Cuvier's beaked whale is the most commonly sighted beaked whale in waters off the western coast of the U.S. Mesoplodont beaked whales are five different species distributed along continental slopes and throughout deep waters in the North Pacific Ocean. Typically seen in small groups, beaked whales are considered to have high sensitivity to anthropogenic sound and long dive times.
Harbor porpoise	The Project area overlaps with the core habitat of the Morro Bay stock of harbor porpoises. This stock is considered a resident population with very limited opportunity for emigration. The stock is typically not encountered south of Point Conception and the coastal areas north of the Project area are considered sub-optimal habitat, with relatively low sighting rates in NMFS surveys. This species has restricted movement into deeper water (greater than 656 feet [200 m]) and

[1] Species listed in *italics* are endangered species. See Section 4.4.1 for additional background on these species.

Species[1]	Rationale for Inclusion in Take Analysis
	exhibits strong coastal habitat preferences in water depths of less than 299 feet (91 m). Harbor porpoises have a summer calving period and presumed fall breeding season. Therefore, the proposed survey period would be considered sensitive for this species (e.g., while calves are being nursed). Based on a wide range of laboratory and field studies, this species is considered very sensitive to anthropogenic noise effects on behavior and hearing.
Dall's Porpoise	The population of Dall's porpoises is widely distributed across the continental shelf, slope, and deep ocean habitats (mainly at depths greater than 328 feet [100 m]). The distribution of this species is highly variable from year to year and season to season. Although Dall's porpoises appear to be affected by oceanographic conditions, they would likely be present locally within the Project survey period.
Pacific white-sided dolphin	Pacific white-sided dolphins are found in cold, temperate waters of the North Pacific Ocean. They become most abundant in shallow, shelf waters off southern California from November to April. This species is generally found in deeper water offshore, but can occasionally be seen fairly close to shore.
Risso's dolphin	The distribution of Risso's dolphins is highly variable, apparently in response to seasonal and inter-annual oceanographic changes. Dolphins found off California during colder water months are thought to shift northward as water temperatures increase in late spring and summer. There are likely to be Risso's dolphins near shore year-round within the Project area. This species is the most-often-sighted cetacean in the Project area, with 364 local sightings during recent surveys. This species primarily feeds on squid.
Northern right whale dolphin	Northern right whale dolphins generally occur offshore, but have also been seen fairly close to shore in the Project area, with PG&E reporting 10 sightings (2011b). Northern right whale, Risso's, and Pacific white-sided dolphins are often seen together in groups, with most groups ranging between one and 300 dolphins.
Bottlenose dolphin – California coastal	The small California coastal stock of bottlenose dolphins ranges from northern Baja California to Central California. Core habitat for this species is located primarily off southern California and Mexican waters, but these dolphins also use habitat in central California during warm-water periods. The Project area is considered within the northern part of the species' range.
Sperm whale	Sperm whales are the only ESA-listed odontocete. Population trends for this species are unknown. Sperm whales have been reported year-round off California, with peak numbers appearing from April through mid-June, and again from the end of August into mid-November. Off California, sperm whales frequent deep offshore waters, although they sometimes venture into shallow water. One group of six or more animals was sighted less than 25 nm (46 km) off Buchon Point.
Harbor seal	Harbor seals are a widely distributed coastal species. They are considered a resident species within the Project area, typically foraging for fish and cephalopods near shore. Pupping generally occurs from March to June and molting generally occurs between May and July. Haul-outs with high counts (approximately 50 to 300 individuals) were recorded in the vicinity of Cayucos Point, Diablo Canyon, Estero Point, China Harbor, Morro Bay Estuary, Fossil Point, South Point, Point San Luis, and Point Buchon.
California sea lion	The population of California sea lions found within the Project area is considered large for the U.S. stock and is seasonally abundant in central California. In the fall, there is typically a northward post-breeding migration of mainly males and sub-adults. These sea lions typically forage within 20 nm (37 km) of shore.

Gray whales and the Southern sea otter were evaluated in this EIR and the Mammal Technical Report, but quantitative take estimates were conducted in a different manner due to their extreme seasonality in occurrence or lack of strong evidence of disturbance from seismic surveys. The southward transit through the Project area of the Eastern North Pacific Stock of gray whales is estimated to start mid-December (December 15) and peak in mid-January (January 15). Small numbers may migrate through the area prior to the predicted start of migration but the majority of individuals in the population are likely to pass through the Project area in less than 24 hours, with limited feeding expected to take place. Because of the Project's timing, this species is not expected to be present and take estimates are expected to be near zero.

The assessment of potential take of sea otters required an alternative technique, given their localized distribution and a review of potential stressors. Malme et al. (1984) did not observe any disturbance response or change in foraging behavior in sea otters exposed to seismic air gun noise. The typical distance between the sea otters being observed and the sound source was 0.8 to 0.9 miles (1.3 to 1.6 km). On one occasion, this distance was as close at 2,952 feet (900 m). However, to be conservative, an acoustic take estimate was computed for this EIR using the 180 dB rms isopleth. For this analysis, a maximum 180 dB rms radius for production lines (2,808 feet [856 m]) and mitigation turns (150 feet [46 m]) to buffer the survey tracks was taken from the Underwater Noise Assessment (Appendix I). A take level based on the potential disturbance effect from the physical presence of vessels on sea otters was also calculated.

Animal Density Estimation

For each of the 16 marine mammal species listed in Table 4.4-9, expected densities of the species in the Project area were estimated. In consultation with NOAA-NMFS scientists, the Strategic Environmental Research and Development Program – Spatial Density Support System (SERDP-SDSS) Density Model was applied for most cetaceans. For gray whales, the most recent stock assessment and timing of the southbound migration were used to estimate the number of whales likely to be in the Project area. Harbor porpoise (Morro Bay stock) are restricted in their distribution and have been systematically surveyed by NOAA. For harbor porpoise, data were provided by scientists at NOAA-NMFS.[2] Sea otter densities were calculated from the USGS Western Ecological Research Center's Spring 2010 survey results. The animal density estimation process is described in Appendix H (Marine Mammal Technical Report, Section 3.2).

[2] Dr. K. Forney (NOAA NMFS SWFSC) provided a GIS layer (shapefile) with harbor porpoise distribution and densities (based on stock survey data from Carretta et al. 2009).

Criteria for Injury and Disturbance Effects

Dual criteria were developed for and applied in this analysis: statutory levels used by NMFS and criteria adapted from Southall et al. (2007).

The MMPA defines two levels of harassment: Level A harassment covers activities with the potential to cause physical injury, while Level B harassment involves the potential for behavioral disruption. NMFS subsequently developed thresholds for assessing potential auditory and behavioral, which are presented in Table 4.4-10 and were used to assess potential impacts on marine mammal species in this EIR.

Table 4.4-10 NMFS Criteria for Level A and Level B Harassment

NMFS Level of Harassment	NMFS thresholds dB re 1 µPa (rms, un-weighted)
Level A	190 (pinnipeds) 180 (cetaceans)
Level B	160

In addition to applying the NMFS criteria, the analysis presented in this EIR used a modification to the NMFS approach for estimating Level A and Level B harassment derived from Southall et al. (2007). The modified approach for Level A harassment considers both sound exposure over the duration of the survey, or cumulative sound exposure levels (SEL), and marine mammal hearing sensitivities. The cumulative SEL is described in this EIR as the *Injury SEL* when it is used to estimate Level A harassment, which addresses physical injury. The modified approach for estimating Level B harassment uses noise thresholds for different types of cetaceans, and assumes a portion of the population will respond to these noise levels. Because a proportion is applied to the criteria, they are referred to as *probabilistic disturbance* thresholds.

Why are the NMFS and Southall et al. Level A Criteria Different?
The main reason for the differences in the Level A criteria numbers is they use different measures. The NMFS criteria use “rms” or root mean squared values of noise levels, which represent averaged levels. The “derived Southall criteria” thresholds account for the peak of the noise impulse, and the exposure to total sound energy (SEL) over time.

Table 4.4-11 provides the *Injury SEL* thresholds used for the Project to estimate Level A harassment, and compares these thresholds with those published in Southall et al. (2007). Table 4.4-12 summarizes the thresholds and the probability of a Level B behavioral response based on data presented in Southall et al. (2007) and new scientific findings.

Table 4.4-11 Derived and Southall et al. (2007) Level A SEL Thresholds

Marine Mammal Group	Injury SEL thresholds (dB re 1 μPa^2-s)	Southall et al. (2007) Published SEL (dB re 1 μPa^2-s)
Low-frequency cetacean	192	198
Mid-frequency cetacean	198	198
High-frequency cetacean	179	198
Pinniped (in water)	186	186

Table 4.4-12 Southall Level B Probabilistic Disturbance Thresholds Developed from Southall et al. (2007) and Newer Sources

Marine Mammal Group	Probabilistic Disturbance rms thresholds M-weighted dB re 1 μPa (rms)			
	120	140	160	180
Porpoises/beaked whales	50%	90%		
Migrating mysticete whales	10%	50%	90%	
All other species/behaviors		10%	50%	90%

Appendix H (Marine Mammal Technical Report, Section 3.9) provides more detail on the development and application of these thresholds in this analysis.

Criteria for Assessing the Severity of Level A and Level B Harassment and Acoustic Take

The criteria discussed above establish a means of relating noise generated by the Project to physical injury (Level A) and disturbance (Level B) of marine mammals expected to be present in the Project area. Because “harassment” results in “take” under the MMPA, most of the discussion in this EIR focuses on Level A or Level B take. In the assessment of noise impacts, take resulting from noise is also referred to as “acoustic take.”

This analysis also considered the potential severity of the effects on populations in two ways:

- Severity, Level A – This analysis assumes all Level A take may cause eventual mortality (whether indirectly or directly), which is likely to overestimate the impact. To put this into the context of effects on a population, the take estimates in this EIR are compared to Potential Biological Removal (PBR). According to the MMPA, PBR is defined as, “...the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population.” PBR was initially intended to serve as an upper limit guideline for fishery-related

mortality for each species, and is used here as a similar means of considering human-caused mortality. The term "residual PBR" takes into account other known sources of human-induced mortality.

- Severity, Level B – The magnitude of Level B take was assessed using the percentage of the minimum stock population affected. The use of the minimum stock population is also precautionary.

Severity of Level A and Level B "acoustic take", which were applied to the NMFS and derived Southall approaches, are shown in Table 4.4-13.

Table 4.4-13 Severity Criteria for Level A and Level B Take

Severity Level	Level A	Level B
Negligible	Less than or equal to 10 percent of residual PBR	• Less than or equal to 5 percent of regional minimum population, or • Less than one ESA-listed animal
Low	10 to 50 percent of residual PBR	• 5 to 15 percent of regional non-listed species minimum population, or • One ESA-listed animal and less than 1.25 percent of the ESA-listed minimum population
Moderate	50 to 100 percent of residual PBR	• 15 to 25 percent of regional non-listed species minimum population, or • 1.25 to 2.5 percent of the ESA-listed regional minimum population
High	Greater than 100 percent of residual PBR	• Greater than 25 percent of regional non-listed species minimum population, or • Greater than 2.5 percent of the ESA-listed regional minimum population

A more detailed description of PBR and how it has been applied in this analysis is provided in Appendix H (Marine Mammal Technical Report, Section 3.3).

Estimate Take Using Noise Modeling Results

The noise modeling results, which estimate survey-generated noise levels in the Project area, were used to assess both pulse sound levels and cumulative exposure. The criteria and severity thresholds discussed above were applied to the modeled noise levels.

4.4.5 Impact Analysis and Mitigation Measures

The following subsections describe the Project's potential impacts on marine biological resources; where impacts are determined to be significant, feasible mitigation measures (MMs) are described that would reduce or avoid the impact. The offshore Project activities would occur within an area extending approximately 15 nm (27 km) from shore. Portions of the Point Buchon, Cambria, and White Rock MPAs lie within the Project area. In addition, the Monterey Bay National Marine Sanctuary (MBNMS), a Federal-protected marine sanctuary that extends northward from Cambria to Marin county, is located within the northern portion of the Project area; survey track lines would not extend into the MBNMS. In addition to the seismic surveys themselves, survey-related activities that could affect marine wildlife would include mobilization/demobilization of the survey equipment, sound checks/verification, and support vessel movements. Along with the air gun operations, two additional acoustical data acquisition systems would be operated continuously from the survey vessel: a multibeam echosounder (echosounder) and a sub-bottom profiler (profiler). The specifics of the proposed survey equipment are provided in Section 2.0 – Project Description and Appendix C – Equipment Specifications.

~~Geophones would be placed in the nearshore area, in water depths of up to approximately 66 feet (20 m) using a vessel and, in some locations, divers.~~ For the nearshore survey area, where it is too shallow for towed arrays, geophones would be placed on the seafloor by hand to record seismic responses from on- and offshore seismic sources. Lines of disc-shaped geophones strung together on cables would be placed on the seafloor along the routes depicted on Figure 2.2-2, at depths up to approximately 425 feet (130 meters). PG&E estimates that approximately 600 geophones would be deployed for the Project.

As included in the Geophysical Survey Permit application materials (PG&E 2011b), the proposed survey would occur between September and December 2012, once the survey vessel[3] had arrived in the Project area. PG&E estimates that the offshore seismic activities would be completed within an 82-day period (assuming operations

[3] PG&E is currently in negotiation to secure the services of the *Langseth* to perform the proposed offshore survey activities. The *Langseth* (and her associated characteristics, such as size and speed) is considered typical of vessels appropriate for use in seismic surveys. For the purpose of this EIR, whenever the *Langseth* is specifically noted, the substitution of a different, comparable vessel would be consistent with the impact evaluation in this document.

would be conducted 24 hours per day, 7 days a week), including mobilization and demobilization. Of this, PG&E estimates that the actual survey would be conducted over 65 days, including anticipated interruptions for equipment maintenance, vessel refueling, and additional shutdowns for crew changes, unanticipated weather delays, or in the event a marine mammal were present. PG&E anticipates that it would be necessary for the survey vessel to refuel once during the survey, at Port Hueneme, outside of the Project area. The specifics of the air gun and hydrophone towing configuration and operation are provided in Section 2.0 – Project Description.

Applicant Proposed Measures

As noted above, if the Project were to be implemented, noise and other Project characteristics could have adverse impacts to marine wildlife. Potential Project impacts to marine wildlife would include direct effects such as auditory damage, vessel collision, oil effects and entanglement, as well as a number of indirect effects such as habitat disturbance or destruction, auditory disturbance/masking, displacement, secondary prey effects, and contamination. The implementation of the APMs described in this subsection would reduce potential impacts to marine wildlife.

One element of the Project is PG&E's development and proposed implementation of a Marine Wildlife Contingency Plan (MWCP) that includes measures designed to reduce the potential impacts on marine wildlife during Project operations (PG&E 2011b). This MWCP, presented in Appendix D, would be implemented in compliance with measures developed in consultation with NMFS. The vessel-based operations of the PG&E MWCP were designed to meet the anticipated requirements of Incidental Harassment Authorization and Letter of Authorization permits that PG&E will need from the NMFS and USFWS, respectively, and to meet any other stipulation agreements between PG&E and other permitting agencies (PG&E 2011b).

PG&E shall implement the following additional measures during the Project to provide worker awareness of biological resources, to identify any significant biological resources present in the work areas, and to modify Project activities in order to reduce or avoid impacts to significant biological resources, if present (PG&E 2011b):

APM-1 Survey Timing. To be less disruptive to migrating and summer season whales, the survey shall be timed to occur during the months of September through December.

APM-2 Establishment of Safety Zone and Exclusion Zone. PG&E used acoustic models to predict sound levels associated with the air gun array, and this information was used to establish both a Safety Zone (the distance from the air gun array at which noise levels are >160 dB re 1 μPa) and an Exclusion Zone

(the distance from the air gun array at which noise levels are >180 dB re 1 μPa) in marine waters around the air guns. The survey vessel shall avoid the presence of sensitive marine wildlife (marine mammals and turtles) within the Exclusion Zone to the maximum extent feasible.

APM-3 Real-Time Sound Measurements/Exclusion Zone Adjustments. An acoustics contractor shall perform real-time, direct underwater sound measurements during air gun deployment; these data shall be used to verify and adjust the Exclusion Zone distances, as needed.

APM-4 Use of Ramp-Up Process. To warn marine wildlife in the vicinity of the air guns and provide time for them to leave the area and avoid potential injury or hearing impairment, at the start of air gun operations (after a period of no operation), the seismic operator shall start off with low sound levels and gradually increase them (ramp up).

APM-5 Air Gun Operation During Turns and Transects. During turns or brief transits between seismic transects, the seismic operator shall continue firing a single air gun to avoid periods of silence when marine wildlife could otherwise attempt to migrate into the Exclusion Zone.

APM-6 Aerial Surveys to Identify Presence of Marine Mammals. PG&E shall conduct aerial surveys as follows:

(1) Approximately ~~1 week~~5 days prior to seismic survey to obtain pre-survey information on the numbers and distribution of marine mammals in the seismic survey area;

(2) During initial stages of seismic survey to document changes in the behavior and distribution of marine mammals in the area during seismic operations. If needed, aerial surveys shall be extended for a longer period of the seismic surveying; and

(3) One week prior to completion of seismic survey to document whether detectable changes in numbers and distribution of marine mammals have occurred in response to the seismic operations.

APM-7 Use of Marine Mammal Monitors During Surveys. Qualified Marine Mammal Observers (MMOs) shall be onboard the primary seismic vessel whenever the air guns are firing during daylight, and during the 30-minute periods prior to ramp-ups, as well as during ramp-ups. Their role shall be to watch for and identify marine mammals; record their numbers, distances, and reactions to the survey operations; and document observations.

A scout vessel with qualified MMOs shall traverse the Exclusion Zone to monitor marine wildlife within the survey area and report to primary vessel operator if any animals are observed.

If marine mammals or other sensitive wildlife are observed within or about to enter the Exclusion Zone around the survey activities, the speed of the vessel shall be adjusted to avoid entry of the marine mammal into the Exclusion Zone. If the mammal still appears likely to enter the Exclusion Zone, further mitigation actions shall be taken, including reducing the number and volume of air guns firing, or complete air gun shutdown.

APM-8 Use of Passive Acoustic Monitoring. Passive Acoustic Monitoring (PAM) shall be available to supplement visual monitoring in conditions of poor visibility or low lighting. When a vocalization is detected while visual observations are in progress, the acoustic MMO will contact the visual MMO immediately, to alert him/her to the presence of cetaceans (if they have not already been seen), and, if necessary, to allow a power down or shutdown to be initiated.

APM-9 Deployment of Nearshore Geophone Lines by Diver-Biologists. A team of diver-biologists have performed a survey in the proposed geophone line locations for the presence of black abalone.

Within 2 days of the actual placement of the geophones, a team of diver-biologists shall survey the alignments to confirm avoidance of impacts to black abalone.

Deployment of geophone lines within rocky areas, in water depths of 10 feet (3 meters) or less would be completed by divers who would pull the line from a boat and place each geophone to avoid any previously marked or observed black abalone.

APM-28 Relocation of Geophones by Divers. In the event a geophone transect is to be relocated, PG&E shall conduct a survey of the proposed new geophone transect; identify locations where geophones can be placed that avoid hard bottom habitat; obtain approval of the new transect from CSLC; place the geophones within the new transect so as to avoid hard bottom habitat; and conduct a post-installation survey to verify avoidance of significant impacts.

Impact Analysis

This EIR identified and evaluated potential impacts to marine biological resources due to the Project as discussed below.

Impact MARINEBIO-1: Vessel transit during mobilization and demobilization activities would potentially disturb or kill (due to collision) sea turtles, fish, or marine mammals. (Less than Significant with Mitigation)

The R/V *Langseth*, R/V *Sea Trek*, and M/V *Dolphin II* would mobilize to the Project area from San Diego, approximately 240 nm (444 km) from Morro Bay. The cruising speed of the *Langseth* when not towing seismic gear is up to 12 knots (22 km per hour) and transit from San Diego is expected to require about 6 days. The M/V *Michael Uhl* (or similarly sized local vessel) would also travel within the Project area during mobilization and demobilization activities. The cruising speed of the *Michael Uhl* is 8.5 knots (16 km per hour), with a maximum speed of 10 knots (18.5 km per hour).

Sea turtles, fish, or marine mammals could be disturbed or struck by the vessels during mobilization to the Project area. As reported in Jensen et al. (2003), of 11 species of whales known to be hit by ships, fin whales (*Balaenoptera physalus*) are struck most frequently; right whales (*Eubalaena glacialis* and *E. australis*), humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter catodon*), and gray whales (*Eschrichtius robustus*) are also commonly hit. Of 292 large whale ship strikes reviewed in 2004, a total of 48 were known to result in injury and 198 resulted in mortality. No injuries to the whale were reported in only seven ship strike cases. The average vessel speed in 58 of the reported cases that resulted in ship strikes was 18.6 knots (34.4 km per hour), with speed ranges falling into one of three categories: 13 to 15 knots (24 to 38 km per hour), 16 to 18 knots (29.6 to 33.3 km per hour), and 22 to 24 knots (40.7 to 44.4 km per hour) (Jensen et al. 2003).

The timing of the survey, when fewer whales would likely to be in the Project area, as described in APM-1, would reduce potential impacts to migrating whales.

As described in APM-6 <u>and modified in MM MARINEBIO-12a and -12b (presented under Impact MARINEBIO-12)</u>, fixed-wing aircraft (such as a Piper Seneca Twin or Cessna 172) would be used to monitor sea life activities within the Project area prior to the survey, during the initial survey stages, and up to 1 week after the offshore survey is completed. These flights would be conducted from approximately 850 feet (240 m), following an established grid in order to monitor for sea life, particularly marine mammals. The information about marine mammals documented within the Project area during the pre-survey flight (during Project mobilization) would also provide a means of alerting the vessels to the presence of marine mammals.

Turtles are slower-moving animals and it may be more difficult for them to swim fast enough to avoid vessels; however, they spend much of their time submerged, thus reducing the potential risk of collision (MMS 2004). The highest concentrations of green sea turtles and leatherback turtles off the California coast occur between July and

September; the olive ridley sea turtle is rarely seen (see Subsection 4.4.1). Disturbance of sea turtles during transit could result in short-term avoidance behavior, but would not result in adverse effects on survival or reproduction. Thus, impacts on sea turtles during mobilization and demobilization would be *Less than Significant*.

Fish are likely to avoid a transiting vessel, thus resulting in only temporary disturbance of fish species. Therefore, the potential fish disturbance or mortality from vessel strikes during mobilization and demobilization would be *Less than Significant*.

As noted above, the Project-related vessels would typically travel at speeds of approximately 10 to 12 knots (18.5 to 22 km per hour), which is lower than the range of speeds associated with marine mammal collisions (greater than 13 knots [24 km per hour] [Jensen et al. 2003]) during transit to the site. However, lethal collisions, even with slow-moving survey boats, have recently occurred in the region and the risk of collisions may increase at night when surface feeding rates increase.

During mobilization and demobilization, the survey vessel's activity would be equivalent to that of similar vessels in the area, such as fishing boats and commercial vessels. As mentioned above, the maximum speed of project-related vessels during transit would be lower than speeds associated with documented vessel strikes noted in Jensen et al. (2003). Although the vessels have the potential to strike mammals, the likelihood would be low given the possible speeds of travel. To reduce this possibility, the following MM shall be incorporated into the Project:

> *MM MARINEBIO-1 Marine Species Protocols.* Pacific Gas & Electric Company shall prepare protocols to be implemented by all Project-related vessels for non-survey transit for the entirety of the Project. These protocols shall include procedures for maintaining safe distances when mammals are observed and for reporting all physical contact and near-misses that may occur during mobilization and demobilization. If marine mammals are observed, the vessels shall maintain a distance of at least 1,640 feet (500 meters) from the mammals to reduce the chance of collision.

Implementation of MM MARINEBIO-1 would reduce the likelihood of marine mammal disturbance or mortality during vessel transit to *Less than Significant*.

Impact MARINEBIO-2: Potential damage to marine habitats (including fish and sea turtle habitat) and invertebrates would occur during the mobilization and demobilization activities. (Less than Significant)

Placement and subsequent retrieval of geophones and associated cables during mobilization and demobilization activities may result in damage to marine habitats.

Geophones would be deployed from Morro Bay by the M/V *Michael Uhl* (or similarly sized local vessel) in the nearshore area, in water depths of up to approximately ~~66~~425 feet (~~20~~130 m) using a vessel and, in some locations, divers. PG&E estimates that approximately 600 geophones would be deployed for the Project. Deployment of geophones would take approximately ~~6~~5 days total. Each geophone is approximately 15 inches (38 cm) in diameter, 6 inches (15 cm) tall, and weighs 65 pounds (25 kilograms) when wet. As listed in more detail in Table 2.6-1, the number of geophone units per receiver string varies from 88 to 140. Likewise, the length of the receiver cable also varies, ranging from 2.7 miles (4.4 km) to 4.3 miles (7 km). These receiver strings would rest on the sea floor. The proposed corridors for geophone placement were surveyed in 2011. The surveyed areas and proposed corridors are provided in Appendix L

As described in APM-9, geophone line placement in locations with rocky substrate in depths of 10 feet (3 m) or less would be conducted by divers to avoid contact with black abalone. In other locations, the geophones would be ~~dropped~~ deployed from the boat along the desired geophone line placement. As described in APM-28, if geophones need to be moved to avoid potentially sensitive marine habitat, PG&E would work with the CSLC to avoid or minimize impacts by carefully selecting transects to avoid hard-bottom habitat and to conduct post-installation surveys to monitor potential impacts. These geophone lines would remain in place throughout the on- and offshore seismic surveys. Once the surveys were complete, marine geophones would be retrieved by the M/V *Michael Uhl* from the seafloor at the conclusion of the 3D survey. Following recovery of the nearshore geophones and cables, the equipment would be transferred back to Morro Bay Harbor for transport off site.

The weight of the geophones and cables (i.e., receiver strings) could impact the seafloor or benthic invertebrates by crushing them. However, the total area of seafloor disturbed would be relatively minor considering the cable placement would be temporary (from September to December) and cover a limited number of narrow, linear bands along the seafloor. Remnants of the activity may leave depressions or holes in the benthos, though these changes would not be expected to be permanent. No overall changes in species composition, community structure, and/or ecological functioning of bottom communities would be expected. The placement and removal of geophones and receiver cables could produce sediment disturbance, but the disturbance would be localized. Areas of hard substrate are present within the proposed geophone corridors. Pinnacles and areas of high vertical relief would be avoided during deployment (based on prior mapping and use of the vessel's depth sounders). The geophone footprint would be limited and the presence on the seafloor temporary (PG&E 2012c).

Indirect effects to fish and sea turtle habitat, and associated prey or other food in shallow-water areas, could occur from deployment of geophones and cables. However, the deployment activities would be limited in scope and duration, and would not result in

permanent damage or changes to fish or sea turtle habitat. Therefore, the potential overall effect of geophone and cable placement on marine habitats would be *Less than Significant*.

As discussed in Section 4.4.1 under the Invasive Species subheading, Caulerpa (*Caulerpa taxifolia*) is a highly invasive green alga that is known to have caused ecological damage by supplanting native seaweeds, sea grasses, reefs, and other communities. The Caulerpa Control Protocol jointly developed by the NMFS and the CDFG (NMFS 2008) requires that project sites in southern California bays and harbors be surveyed for Caulerpa before conducting activities involving seafloor disturbance. This protocol applies to portions of the offshore Project area, and PG&E will need to assess the need for protocol-level surveys of Caulerpa in their Project-related consultations with NMFS and CDFG. Given the established procedures and the low likelihood of encountering Caulerpa during Project activities (see Section 4.4.1), impacts associated with this species are considered *Less than Significant*.

Impact MARINEBIO-3: Disturbance of fish, sea turtles, and marine mammals would occur during deployment of geophones and cables. (Less than Significant)

Deployment of geophones and cables from Morro Bay by the M/V *Michael Uhl* (or similarly sized local vessel) could disturb or displace fish, sea turtles, or marine mammals that may be present in the Project area. In general, fish and marine mammals are able and expected to avoid these activities and equipment. In addition, as described in APM-6, a survey for marine sea life using a fixed-wing aircraft would be conducted 1 week prior to mobilization and this survey would be repeated 1 week prior to the final seismic survey and demobilization. Marine mammals documented within the Project area during the pre-survey flight could be avoided during geophone deployment by using a different transit route or slower vessel speed to reduce to potential for interactions. Furthermore, as noted in Section 2.6, MMOs would monitor the deployment and recovery of all Project-related equipment, which would occur during daylight hours. These MMOs would look for and note the presence of marine mammals, if any, within the work area and would direct activities to avoid impacts to them.

Approximately 20 miles (32 km) of geophone cables would be laid from a vessel offshore of the DCPP. This area has a high density of sea otters, especially near shore. The total otter habitat encompassed by these geophone cables is roughly 50 square miles (81 square km), containing an estimated 173 animals (see Appendix H). However, the limited area affected by the support vessel and divers is not expected to disturb numerous individuals.

Related potential disturbance or displacement of fish, sea turtles, or marine mammals would result in short-term avoidance behavior, but would not adversely affect the long-

term reproduction of these species. Therefore, potential disturbance effects of geophone and cable deployment on fish, sea turtles, and marine mammals would be *Less than Significant*.

Impact MARINEBIO-4: Disturbance effects of artificial vessel lighting on fish, sea turtles and marine mammals would occur during offshore seismic survey activities. (Less than Significant)

Offshore seismic activities would occur 24 hours per day; thus, lighting would be required on the vessels during nighttime activities. Night lighting could be detrimental to animals in nearby areas for a variety of reasons, including disruption of circadian rhythms, disruption of melatonin levels, avoidance due to light sensitivity in species with exceptional night vision, or increased predation (Bier 2006). Artificial light could result in unnatural fixation on or repulsion to the light source, resulting in a disruption of natural behavior (Rich and Longcore 2006). Because vessels used for the seismic survey would be mobile, rather than fixed, the potential for marine life to become fixated or repulsed by navigation lights would be notably reduced.

Most studies of the effects of artificial lighting on sea turtles focus on lighting located on turtle nesting beaches. Female turtles could be deterred from emerging from the ocean and hatchlings may be disoriented due to artificial lighting. Hatchlings tend to orient toward the brightest direction, which on natural, undeveloped beaches is commonly toward the broad open horizon of the sea. However, on developed beaches, the brightest direction is often away from the ocean and toward lighted structures. Hatchlings suffer high mortality if they are unable to find the ocean, or are delayed in reaching it, due to dehydration, exhaustion, predation, or even being crushed by motor vehicles (NMFS 2011s). In places like Florida and Queensland, Australia, significant decreases in turtle nesting have been recorded as development has resulted in more lighting along nesting beaches (Western Australia Environmental Protection Agency 2010). As there are no known turtle nesting beaches located within the Project area, the potential for effects on nesting female turtles or turtle hatchlings would not be expected.

The effects of artificial light on fish vary greatly by species, but can result in temporary blindness, inhibition of normal anti-predation behavior such as schooling, or altered migratory patterns in species such as salmon and sockeye fry (Rich and Longcore 2006). However, as with sea turtles, less information is available about the potential effects on fish of ship navigation lights that are not fixed in one place.

A study by Fristrup and Harbison (2002) discussed the importance of vision in sperm whale predation on squid, suggesting that the whales may search for prey silhouetted against downwelling light. Vision is important to several prey items that inhabit the mesopelagic (650 to 3,300 feet [200 to 1,000 m]) environment, including fish,

amphipods (tiny crustaceans), polychaetes (worms), and heteropods (snails) (Fristrup and Harbison 2002). This attraction to light could indirectly affect predation by larger species, such as marine mammals, though data are lacking on this topic. Vessel lighting would not be fixed at the surface of the ocean, thereby reducing the potential to attract or repel marine species. Thus, potential effects on sea turtles, fish and marine mammals resulting from transient, periodic light during nighttime seismic operations would be *Less than Significant*.

Impact MARINEBIO-5: Entanglement in the air gun array or other seismic equipment during survey activities would result in mortality or injury of sea turtles or marine mammals. (Less than Significant)

Sea turtles and marine mammals could become trapped by or wrapped around the air gun array, hydrophone streamers, cables, buoys, or other deployed seismic gear, which could cause injury or fatal drowning; however, the likelihood of such entanglement would be low considering the incidence rate of such events. As reported by Weir in 2007 (as cited in NSF 2011), a sea turtle became fatally entrapped between buoys and the vessel during seismic surveys off the coast of West Africa in 2003. According to NSF 2011, no incidents of entanglement of marine mammals with seismic survey gear have been documented in over 54,000 nm (100,000 km) of previous NSF-funded seismic surveys when MMOs were aboard.

To minimize potential exposure of whales to seismic operations, the surveys would occur during a period when whale densities are generally lower (September to December), as stated in APM-1. Visual monitoring as specified under APM-6 (aerial surveys) and APM-7 (MMOs) would further reduce the risk of entanglement by monitoring for marine mammals and other sensitive wildlife near the vessel and towed equipment. Hydrophone streamers towed in the water column would not be long-term features and would not block movement or migration of sea turtles, although a low risk of entanglement would still exist. As specified under APM-7, if an MMO were to observe a marine mammal or other sensitive species in or near the Exclusion Zone, the speed of the vessel would be adjusted to minimize the potential for interference.

In summary, the likelihood of entanglement would be low because of measures incorporated into the Project that would allow for observation and avoidance actions if marine mammals or turtles were present in the survey area, and therefore, the impact would be *Less than Significant*.

Impact MARINEBIO-6: Ship strikes during survey activities would result in mortality or injury of sea turtles or marine mammals. (Less than Significant)

The likelihood of the seismic vessel or towed/deployed equipment striking a sea turtle or a marine mammal would be low, given the average speed of the seismic vessel during operations, which would be slower than its speed during transit (see Impact MARINEBIO-1). While vessel collisions with sea turtles are known to occur, the Project vessel(s) would be moving relatively slowly (4 to 5 knots [7.4 to 9.3 km per hour]) and along predictable courses during most of the seismic acquisition. Based on a report by Weir (2007, as cited in NSF 2011), sea turtles exhibited a startle response and moved away from the seismic vessel and/or towed equipment, but then resumed their previous behaviors after being startled. A total of 13 sea turtles dived in apparent response to the seismic vessel, including nine that startle-dived at the bow (seven while the air guns were off).

As described in more detail in Subsection 3.8.3 of Appendix H (Marine Mammal Technical Report), marine mammals would be expected to respond to seismic vessels during operations by moving away from the vessel while air guns were firing. However, based on data from recent observations in southern California, a small portion of animals may not move away or may move towards the seismic vessel during operations.

Marine mammal sightings have been recorded for recent seismic surveys as follows:

- During a 13-day cruise of the California Bight for a USGS seismic survey in the summer of 1998, shutdowns were made for eight common dolphins and three California sea lions. Of 129 sightings of marine mammals, 27 were noted moving towards the seismic vessel (Calambokidis et al. 1998).
- In summer 2000, during 19 days in the California Bight, shutdowns were made for 29 common dolphins, three Risso's Dolphins, four bottlenose dolphins, three California sea lions, and one blue whale (Calambokidis and Chandler 2000).
- In summer 2002, during 14 days in the Santa Barbara channel and when using a high-power source, shutdowns were made for 20 common dolphins, one Risso's Dolphin, 10 Pacific white-sided dolphins, two California sea lions, four humpback whales, and one blue whale (Calambokidis et al. 2002).
- Stone and Tasker (2006) documented that 6.8 percent of cetaceans were observed heading towards seismic survey vessels firing large arrays; approximately 75 percent of these cetaceans were observed within 1.3 miles (2 km).

In 2007, four blue whales were struck and killed by ships off the coast of California (Calambokidis et al. 2011). A study was conducted by Cascadia Research between 2007 and 2011 that focused on the overlap between shipping lanes and whale distribution off California; key findings indicated that: (1) the overlap between ship and

whale transit routes tended to be near the edge of the continental shelf; (2) blue whales may be more vulnerable at night when resting and feeding near the ocean surface; (3) whales did not avoid closely approaching ships and, in some cases, actually approached vessels; and (4) spending more time near the surface when vessels are close likely made blue whales more vulnerable to ship strikes (Calambokidis et al. 2011).

The relatively low speed of the seismic vessel during the survey (4 to 5 knots [7.4 to 9.3 km per hour]) would help reduce the potential for a collision. However, lethal collisions, even with slow-moving survey boats, have recently occurred in the region (see preceding paragraph) and risk may increase at night when surface feeding rates increase. Implementation of APM-1 (*Survey Timing*), APM-2 (*Establishment of Safety Zone and Exclusion Zone*), APM-6 (*Aerial Surveys to Identify Presence of Marine Mammals*), APM-7 (*Use of Marine Mammal Monitors During Surveys*), and APM-8 (*Use of PAM*) would reduce the risk of collisions with marine mammals during daylight hours. Implementation of APM-8 (*Use of PAM*) would also reduce the risk of collisions with marine mammals during nighttime hours. Marine mammals observed to be in or near the Exclusion Zone would result in an adjustment to vessel speed or, in rare cases, a complete shutdown of air guns if an animal did not appear to be moving away from the Exclusion Zone. Incorporating the abovementioned APMs, the risk of collision with marine mammals in the Project area during the survey is expected to be *Less than Significant*. (See also additional MMs proposed in Impact MARINEBIO-12.)

In general, the risk of collision with sea turtles by seismic vessels would be low, based in part on the number of seismic surveys conducted with no such known occurrences reported (see above). Furthermore, MMOs would watch for sea turtles within the Exclusion Zone and advise ship personnel to avoid collisions. Therefore, the effects of ship strikes on sea turtles would be *Less than Significant*.

Impact MARINEBIO-7: Ingestion of oil due to a potential spill during survey activities would result in mortality or injury of fishes, sea turtles, or marine mammals. (Less than Significant)

As described in Section 4.8 – Public Safety, three vessels would be operating offshore within the Project area and a Notice to Mariners would alert other vessels near the area of the presence of the survey vessels. The three survey vessels would contain fuel, as well as a small amount of lubricants. No refueling would occur within the Project area. As required by the USCG, an Oil Spill Contingency Plan has been prepared for the R/V *Langseth,* the largest of the vessels, which has a fuel capacity of 353,760 gallons (marine diesel) and has a range of 15,534 miles (25,000 km). The vessel would be refueled once during the survey, so there would be two periods when the vessel would be holding near its fuel capacity. At other periods, the fuel load would diminish with time.

In the event of an oil spill, the following actions would be undertaken in accordance with regulations and the vessel's Oil Spill Contingency Plan:

- Deployment of a containment boom available on the vessel, and enlistment of additional support that could be obtained from local harbors;
- Use of protective measures developed to protect sensitive resources and habitats in the Project area, as described in the Area Contingency Plan prepared by the USCG, CDFG, and other resource agencies (CDFG 2009); and
- Activation of local response available from PG&E.

According to MMS (2004), records of spill-related accidents during geophysical and geological surveys indicate that the number of such accidents has generally been low. The characteristics of the environment within the Project area affect the potential for an oil spill to impact marine resources found within the area. For example, oil products can become less toxic as they are exposed to air, sunlight, microorganisms, wave action, and tidal action over time. This process is often referred to as "weathering" and the rate that this may occur depends on factors such as type of oil, weather, temperature, and the type of shoreline and bottom that occur in the spill area (USFWS 2004). Other considerations regarding oil spills and the effects on the environment include:

- Amount spilled;
- Movement of oil;
- Type of oil;
- Use of dispersants;
- Cleanup and containment operations; and
- Resource baseline (i.e., marine mammal, turtle, fish population status).

For marine invertebrates, oil could be directly toxic through physical smothering, alteration of metabolic and feeding rates, and alteration of shell formation. In addition to its potential lethality, the oil could accumulate and be passed on to predators. If oil were to concentrate along the shoreline or in sediments, benthic invertebrates within the intertidal zone could be particularly vulnerable. While oil could prevent the germination and growth of marine plants, most vegetation, including kelp, appears to recover after cleanup (USFWS 2004).

Direct impacts on fish could occur through uptake by the gills, ingestion of oil or oiled prey, mortality effects on eggs and larvae, or changes to fish habitat. Reductions in growth of the liver, impacts on reproduction, fin erosion, or changes to heart or

respiration rates due to oil exposure could also affect adult fishes. Eggs and larvae would be particularly sensitive to high concentrations of oil and oil toxins (USFWS 2004).

In general, exposure of sea turtles and marine mammals to oil from a spill could result in the following:

- Respiratory irritation, inflammation, or emphysema from inhalation of specific volatile organics from some types of oil;
- Gastrointestinal inflammation, ulcers, bleeding, diarrhea, or maldigestion from ingestion of oil;
- Damage to organs such as the liver, kidney, adrenal glands, spleen or brain; development of anemia, cancer, congenital defects, and immune system suppression; or reproductive failure due to inhalation or ingestion of chemicals found in oil;
- Skin and eye irritation; inflammation; burns to mucous membranes, mouth, and nares; or increased susceptibility to infection;
- Fouling of the baleen (used for filtering food) of mysticete whales;
- Disruption of foraging, habitat use, daily or migratory movements, and behavior, or increased risk of vessel strikes due to increased vessel traffic;
- Disturbance or displacement, hearing loss (temporary or possibly permanent), or other physical injury to marine mammals due to noise from response-related activities;
- Inhalation risks or displacement of animals due to booms and skimmers, or in situ burning of oil or oil-soaked materials; and
- Reductions in biomass of marine mammal prey, shifts in prey distribution, or contamination of prey (MMC 2011; NMFS 2011r).

Most cetaceans exposed to an oil spill would be unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin 1980; 1982, as cited in NSF and USGS 2011). Humpback and right whales (Mysticete suborder) that feed in more confined areas, such as bays, could be at greater risk of ingesting oil (Würsig 1990, as cited in NSF 2011). Oil could destroy the insulating qualities of hair or fur of some marine mammals, resulting in hypothermia. Heavy oiling could also cause a decrease in mobility, leaving the animal unable to swim or forage (NSF and USGS 2011). Seals generally keep their nostrils close to the water surface when breathing, so they would be likely to inhale vapors if they surface in a contaminated area (NSF and USGS 2011). Sea otters do not have blubber and rely on their fur for thermoregulation. Oil prevents

their fur from providing the necessary insulation, and therefore sea otters would be especially at risk from a potential spill because of thermoregulation and direct ingestion/inhalation effects (Garrott et al. 1993).

The chances of an oil spill occurring during the seismic surveys would be unlikely given the nature of the activities, the relatively slow vessel speed (4 to 5 knots [7.4 to 9 km per hour] during the survey), that refueling would not occur in the Project area, and the relatively short amount of time the vessels would be in the Project area (approximately 82 days total; 41 days during the survey). Considering the vessel's safety protocols and Oil Spill Contingency Plan procedures, the Project would not likely result in an accident that would result in an oil spill. In addition to the safeguards that would be in place for this specific Project, there are protocols and procedures set forth by the Marine Mammal and Sea Turtle Stranding Networks for responding to live animals that are exposed to oil spills; animals brought into rehabilitation facilities would be provided veterinary care to remove oil and treat any related health effects (NMFS 2011r). Therefore, the potential effects of an oil spill on marine biological resources would be *Less than Significant*.

Impact MARINEBIO-8: Injury or mortality to adult fishes would occur due to noise from air guns during the seismic survey. (Less than Significant)

To acquire sound magnitude data that measured the effects, or a lack of effect, on fish species, a comprehensive literature search was performed using the peer-reviewed scientific literature, agency reports, and unpublished documents available from public sources. The literature reviewed focused on studies that presented a~~n~~ measured actual sound magnitude (typically in dBs) generated from an air gun, and where possible, studies with quantified receiving levels (measured noise at the receptor), as these were the studies that were practicable for evaluating potential effects from acoustic surveying. (A summary of these findings that relate to fishing catch is discussed in Section 4.13 – Commercial Fishing.) Given the dynamic nature of life stages in fish, effects were catalogued separately for adults and juvenile/planktonic stages. This discussion summarizes representative results of the studies reviewed.

Effects characterized in the studies reviewed include mortality, physical injury and hearing effects, and behavioral effects, as summarized below.

No documented instances of fish mortality under field operating conditions were found, and this was consistent within the literature reviewed (Boeger 2006; DFO 2004).

In terms of physiological effects, fish are potentially vulnerable to auditory distortion. Numerous studies have been conducted to analyze the effects of seismic survey noise

on fish hearing. Two such academic studies focused on direct exposure of caged fishes placed next to air guns (McCauley et al. 2003; Popper et al. 2005). The findings of those studies were as follows:

- McCauley et al. found minor effects on the auditory sensory cells of pink snapper (*Pagrus auratus*) exposed to multiple shots of a 20-inch air gun. Effects were found up to 58 days after the exposure. The McCauley et al. study did not test for effects on fish hearing and made no conclusion regarding the consequences of potential damage to a small proportion of auditory sensory cells on fish behavior, mortality, or other physiology.

- In a similar experimental approach, Popper et al. exposed lake chub (*Couesius plumbeus*), northern pike (*Exoxz Lucius*), and broad whitefish (*Coregonus nasus*) to sound shots from a 730-inch air gun array in a shallow (6.2 feet [1.9 m]) freshwater environment. Following exposure, Popper et al. found a Temporary Threshold Shift (TTS) in hearing in the lake chub and northern pike exposed to the air guns, but also showed that both fish species fully recovered from the TTS within 18 to 24 hours after exposure. In a 2008 follow-up study, Song et al. examined the fish exposed during the 2005 Popper et al. study and found that no damage to the auditory tissues could be detected in fish that had shown TTS after 18 to 24 hours post-exposure during the 2005 study.

~~Taken together,~~ ~~t~~These studies provide a strong line of evidence that while sound sources may result in a temporary TTS in the hearing of adult fishes, there are no long-term physiological impacts to fish hearing.

In the most comprehensive study of the effects of air gun noise on fish hearing to date, Hastings et al. (2007) exposed four species of tropical reef fish to sound from a 2,055-cubic-inch seismic air gun in a controlled field experiment with sound sources up to 190 dB re 1 µPa. In this study, fishes were caged during single and double passes of the air gun array during a three-dimensional (3D) seismic survey in Western Australia. Following field exposure to the sound sources, all fishes were subjected to hearing sensitivity tests. Hastings et al. found no significant differences in hearing thresholds among exposure groups or between exposure groups and baseline or control thresholds for any test frequency, even during repeated sound source passes.

Additionally, studies have been performed using video cameras to document behavioral responses of fishes when exposed to seismic sound sources. For example, Wardel et al. (2001) found only a short-term behavioral reaction to the passage of a sound source, to which the fishes displayed a startle response. Similarly, Thomsen (2002) found only a behavioral “fright” response when trout were exposed to a sound source of 142 to 150 dB re 1 µPa.

The use of seismic air guns during survey operations would not be expected to lead to significant injury or mortality to adult fishes within the Project area. As discussed in above, several studies have addressed direct effects of sound sources from seismic survey equipment to adult fishes in both marine and freshwater systems. These studies addressed sound levels well within the range of expected sound levels in the Project area using the proposed equipment spread (see Appendix I – Underwater Noise Assessment). While studies have shown temporary impacts to hearing, including TTS in a variety of fishes, the review conducted for this EIR found no studies have shown long-term physiological or mortality related impacts related to TTS.

Additional studies have shown short-term behavioral effects of sound sources, including a “startle” effect in which fishes will hide or otherwise react to the sound source passing overhead. As with the TTS data, this effect is transitory and no evidence was identified suggesting this short-term behavioral effect results in injury or mortality to adult fishes.

As discussed in Section 4.4.1, steelhead (SCCC DPS, which is Federal-threatened and a State species of special concern) may be present in the Project area during the period of Project implementation. Certain life-history stages (e.g., steelhead eggs, recently emerged fry, juvenile steelhead rearing in freshwater, smolts moving downstream toward the ocean, and adults in pre- or post-spawning freshwater residency) would be upstream, away from the proposed seismic survey area, and are not anticipated to be affected by the Project. Life-stages potentially affected by seismic surveys include (i) adult steelhead migrating back to natal streams to spawn and (ii) smolts and post-spawning adults out-migrating to the ocean. Adult Steelhead typically enter the streams in the Project area ~~in the November to~~from December ~~time frame~~to March, with the peak numbers typically entering natal streams in January/February (Moyle 2002)~~in anticipation of the strongest early storms~~. Therefore, they may be present in the offshore Project area until the river mouths are passable (that is, after the first storms breach the sandbars formed during low flow periods, which cut off the streams from the ocean and prevent steelhead passage). Smolts and post-spawning adults also migrate out of the streams following winter rains, with peak outmigration occurring in March-May (NMFS 2004, 2007). The proposed seismic survey is scheduled to occur prior to reported mean peak flows in the Project area creeks and well before peak adult migration and smolt out-migration periods. Therefore, impacts from the proposed Project on steelhead migrations patterns would be *Less than Significant*. As discussed above, adult ~~fish~~ steelhead are not expected to be harmed by the survey noise. Steelhead larval fishes and eggs would not be present in the offshore Project area, which is a marine environment. (See also the discussion of effect on eggs and larvae under Impact MARINEBIO-9.)

The Project would not be expected to modify habitat of special status species, cause a substantial interference with the movement of a native resident or migratory fish species, or cause a population to to drop below self-sustaining levels. Therefore, the potential for the seismic survey to result in injury or mortality of adult fishes would be *Less than Significant*.

Impact MARINEBIO-9: Injury or mortality to juvenile fishes, larval organisms, and planktonic resources would occur due to noise from air guns during the seismic survey. (Less than Significant)

The potential for adverse impacts on juvenile fishes, larval organisms, and planktonic resources depends on the effects of noise on these resources, as well as their presence during the period when the Project would be conducted.

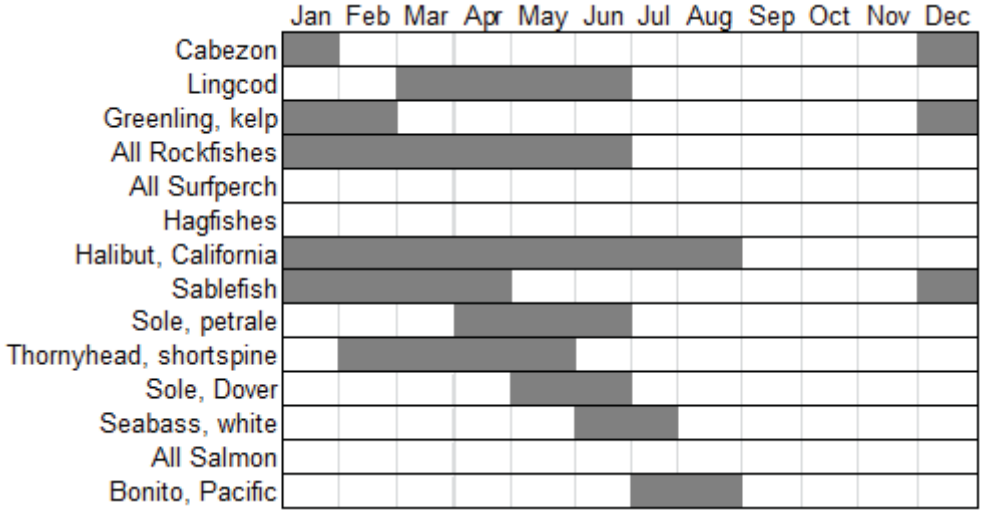
Little information exists documenting the effects of seismic sound sources on juvenile fish, larval organisms, or plankton. As mentioned in the discussion of Impact MARINEBIO-8, the literature review conducted for this analysis focused on studies that presented a measured sound magnitude (typically in dBs) generated from an air gun, and where possible, studies with quantified receiving levels (measured noise at the receptor). In an early study, Kostychenko (1973) found that exposure of anchovy (Family Engraulidae) eggs to a sound source of 230 dB approximately 1 meter (3 feet) resulted in damage to 7.8% of eggs. Matishov (1992) exposed cod (*Gadus morhua*) larvae to sound sources between 222 and 250 dB re 1 μPa and found effects in eye tissues (e.g., delamination of the retina) only at these high sound levels, and approximately 3 feet (1 meter) from the air gun. At 32 feet (10 meters), no injury was detected.

There is also documentation of sound level thresholds below which there was no observable injury to juveniles. The same Kostychenko study (1973) documented no injury to either anchovy (Family Engraulidae) or red mullet (Family Mullidae) eggs after a decrease in sound magnitude to 210 dB. Mastishov (1992) also reported that no injury to cod (*Gadus morhua*) larvae occurred at 202 dB.

The information presented above suggests that large sound magnitudes, on the order of approximately 220 dB at the receptor, would be required to injure juvenile fish eggs or larvae. The zone within which sound levels would be of that magnitude would be limited to the immediate area of the air guns. The population-level effects of a small reduction in eggs or non-fatal injury to larvae is not well documented and not quantifiable based on the current literature. Available literature suggests the injury caused by air guns is small relative to natural mortality and predation (Saetre and Ona 1996, as cited in NSF 2011).

A second consideration regarding this impact is the presence and abundance of these juvenile resources expected during the survey period. Data from regular monitoring programs at the DCPP provide some baseline information about peak seasons for fish eggs and larvae (PG&E 2011b). Data from the online database Fishbase (Froese and Pauly 2012) were also used in validating the estimated presence of larvae for fish species in the Project area. Figure 4.4-3 below shows estimated peak seasonal presence of larvae in the Project area.

Figure 4.4-3 Larval Peak Months, Commercial Fish Species in the Project Area



Sources: Tenera 2011; Fishbase 2012.

As shown in Figure 4.4-3, relative to other times of the year, September to December are not peak months. Note that salmonid eggs and larvae would be in streams or creeks, and not in marine waters.

Based on information available, the effect on fish eggs and larvae are expected to be limited (only at high noise levels and in close proximity to the air guns). Combined with survey timing that would likely avoid peak larval seasons, the overall effect on planktonic resources, including juvenile fishes, would be *Less than Significant*.

Impact MARINEBIO-10: Injury or mortality to marine benthic invertebrates would occur due to air gun noise during the seismic survey. (Less than Significant)

To acquire sound magnitude data that measured the effects, or a lack of effect, on invertebrate species, a comprehensive literature search was performed using the peer-reviewed scientific literature, agency reports, and unpublished documents available from public sources. The literature reviewed focused on studies that presented an actual sound magnitude (typically in dBs) generated from an air gun, as these were the studies that were practicable for evaluating potential effects from acoustic surveying.

These studies suggest that seismic survey noise-generation activities in the Project area would have very little effect on benthic invertebrates, which would be insensitive to these sounds. For example, Pearson et al. (1994) found sound levels between 222 and 244 dB re 1 µPa had no effect on Dungeness crabs (*Cancer magister*) within distances of only 3.3 feet (1 m) from an air gun array. Kosheleva (1992) exposed mussels (*Mytilus edulis*), amphipods (*Gammarus locusta*), and Periwinkle (*Littorina littorea*) to a 223 dB re 1 µPa air gun only 1.6 feet (0.5 m) away and documented no injury.

In an *in situ* study, Wardle et al. (2001) set up cameras and acoustic tags around a natural reef and observed the reef prior to, during, and following exposure to seismic air gun firings with magnitudes as high as 218 dB. No effects on invertebrates were observed.

The evidence presented in these studies suggests that large magnitude sounds from air guns firing would not present a significant risk of injury to marine benthic invertebrates. The studies focused on sound levels up to 244 dB re 1 µPa, a magnitude exceeding the noise levels that would be expected in the Project area (see Appendix I – Underwater Noise Assessment). No published field or laboratory studies with quantitative sound data have shown physiological or pathological effects on marine invertebrates. Therefore, the potential noise-related Project impacts on marine invertebrates would be *Less than Significant*.

Impact MARINEBIO-11: Injury or mortality to sea turtles would occur due to noise during the seismic survey. (Less than Significant)

The auditory sensitivity of sea turtles is not well-studied; however, preliminary investigations suggest that it is limited to low-frequency bandwidths. The role of low-frequency hearing in sea turtles is unclear, though it has been suggested that sea turtles may use acoustic signals from their environment as guideposts during migration and as a cue to identify their natal beaches (Lenhardt et al. 1983, as reported in U.S. Navy 2008).

Ridgway et al. (1969, as cited in U.S. Navy 2008) conducted studies on green turtles and concluded that they have a useful hearing span of perhaps 60 to 1,000 Hertz (Hz), but hear best from about 200 Hz up to 700 Hz, with much less sensitivity below 200 Hz. As reported by the U.S. Navy (2008), a turtle's hearing threshold was about 64 dB in air, at a frequency of 400 Hz. Lenhardt et al. (1983, as cited in U.S. Navy 2008) applied audio-frequency vibrations at 250 Hz and 500 Hz to the heads of loggerheads and Kemp’s ridleys submerged in salt water to observe their behavior and assess any neural-evoked response. While exposed to the maximum upper limit of the vibratory delivery system, turtles exhibited abrupt movements, slight retraction of the head, and

extension of the limbs in the process of swimming (U.S. Navy 2008). Based on these studies, turtle hearing sensitivity appears to be low (Lenhardt 1994, as cited in U.S. Navy 2008).

Two levels of sounds criteria for sea turtles were established by the NMFS for NSF-funded seismic research in areas where high densities of sea turtles were expected (NSF and USGS 2011). Given the lack of relevant data, the NMFS took a precautionary approach in 2009, and set a safety radius for Level A take at 180 dB re 1 μPa, above which TTS or Permanent Threshold Shift (PTS) would be considered possible and should be avoided. For behavioral or harassment effects (Level B take), a radius of 166 dB re 1 μPa was set by the NMFS to reduce the likelihood of harassment (NSF and USGS 2011).

Since 2009, however, limited new data have become available that suggest notably higher sound levels (approximately 175 dB re 1 μPa) would be needed to induce behavioral avoidance. This also could suggest that even higher thresholds would be required to induce PTS or injury, though this is still unknown (NSF and USGS 2011).

For the purposes of this Project, the Exclusion Zone for marine life was based on a safety radius of 180 dB re 1 μPa. The air guns would generate a low frequency of 10 to 120 Hz (see Section 2.5).

The potential for PTS, injury, or lethal effects from air guns is unknown but considered unlikely, as turtles would be expected to avoid such exposure and the exposure would be relatively short-term. In addition, impacts from survey noise on sea turtles at the population level would not be expected, particularly because the Project area is not a nesting area where juveniles would be found. The number of individual sea turtles expected to be closely approached during the surveys would also likely be small in relation to regional population sizes. With the proposed APMs for monitoring, ramp-up, power- and shutdown provisions, effects on those individual turtles would likely be limited to short-term behavioral disturbance. In summary, the Project would likely result in *Less than Significant* impacts on sea turtles within the Project area.

Impact MARINEBIO-12: Injury or mortality to marine mammals would occur due to noise during seismic survey acquisition. (Significant and Unavoidable)

The potential impacts of anthropogenic noise on marine mammals may vary from no effect to potentially lethal. A large amount of research over the last two decades has attempted to quantify these effects. There are a number of reviews on this subject summarized in Appendix I that focus specifically on recent and relevant reported effects from seismic surveys. For a species to be affected by noise, the amplitude, duration and frequency of the noise influence how the animal is affected. It is also important to

consider the hearing ability and behavioral state of the animal to determine how sensitive it may be to the noise as well as whether the animal is likely to be in the vicinity of the noise source. Potential effects of noise may be classified into the following categories:

- Masking;
- Behavioral disturbance;
- Temporary hearing loss (TTS) or permanent hearing loss (PTS); and
- Other physiological effects (e.g., stress or immune response).

NMFS thresholds and additional criteria used in this EIR for estimating Level A and Level B acoustic take were summarized in the Methodology discussion earlier in this subsection.

This subsection provides an overview of the results of the assessment of potential impacts of noise on marine mammals and is organized as follows:

- Overview of Level A Acoustic Take Estimates;
- Overview of Level B Acoustic Take Estimates;
- General Summary of Acoustic Take Results; and
- Results for Individual Species or Species Groups Analyzed.

This summary of take estimates was derived from noise modeling (presented in detail in Appendix I – Underwater Noise Assessment and summarized in Section 4.11 – Noise). Following this summary, impact assessments are provided for specific species and species groups.

Overview of Level A Acoustic Take Estimates

As presented in Subsection 4.4.1 and described in detail in the Marine Mammal Technical Report attached as Appendix H, Level A acoustic takes were calculated using two different sets of thresholds, NMFS *Minimum* and *Maximum*, and *Injury SEL*.

The numbers presented in Table 4.4-14 for the NMFS *Minimum* (Individual Exposure) threshold exposures represent an estimate of the minimum number of individual takes; however, do not take into account potential overlap in the area that may be ensonified (exposed to survey noise) during the seismic survey. For example, as shown in Figure 2.5-8, the proposed seismic lines run parallel to each other in close proximity (1,312 feet [400 m]); as a result, there are areas were radii overlap (often multiple times). Because of this overlap, an individual mammal, if it remained in the same place, may theoretically be exposed to noise numerous times during the survey, resulting in multiple takes. The

NMFS *Maximum* threshold exposures include the areas of overlap when estimating the take. The ratio of *Minimum* and *Maximum* exposures, as an indicator of the intensity of the total survey exposure, are also shown in Table 4.4-14.

For both Level A acoustic take criteria, three scenarios for population density have been modeled (Base, Upper, and Potential) and are reported in Appendix H. The density scenarios modeled are as follows:

- Base – mean densities;
- Upper – mean densities weighted by 90 percent confidence limits or one Standard Deviation; and
- Potential – density prediction that factors in potential density variability by considering a conservative "turnover" rate (i.e., the rate at which individual animals of a certain species may move in and out of an area), as well as a correction factor for humpback whales. The humpback whale correction factor is based on expert comments received on the SERDP-SDSS Model density estimates.

The following key assumptions regarding marine mammal density estimates were applied:

- The species-specific minimum depth cut-off; depth cut-offs were applied to five species (blue whales, beaked whales, Dall's porpoise, Northern right whale dolphin, and sperm whales), below which the density is assumed to be zero;
- Maximum depth cut-off for harbor porpoise is 656 feet (200 m);
- Density of harbor porpoise varies by depth, with higher densities shallower than 50 fathoms (91.5 m); and
- California Coastal bottlenose dolphins were limited in distribution to within 0.6 mile (1 km) of the coast.

In order to estimate the level of acoustic take for each species, the following parameters were considered:

- Area ensonified by the air guns (single or multiple) to the predetermined depth strata-specific noise threshold criteria. Figures 4.4-4 through 4.4-7 show the cumulative SEL modeling results for survey blocks 1 through 4, respectively. The modeling results are discussed in more detail in the Marine Mammal Technical Report (Appendix H) and Appendix I (Underwater Noise Assessment).
- Length or area of the survey track.
- Density estimate for each species (see Section 3.2 of Appendix H, Marine Mammal Technical Report).

- Weighting factors that take into account the APMs and additional proposed MMs (Level A only) (e.g., the ability of MMOs to detect marine mammal species within or near the Exclusion Zone).
- Marine mammal behavioral response (Level A only); an avoidance response factor of between 90 and 99 percent (depending on the species) was applied to account for avoidance of the zone within the Level A threshold.

For special status species, levels of take calculated for each density scenario under the various criteria as shown in Table 4.4-16 below were compared with residual PBR for that species. The colors in the table represent various levels of effect, including high (red, >100 percent of residual PBR), medium (orange), low (yellow), and negligible (no color).

Following Table 4.4-14, Figures 4.4-4 through 4.4-7 present noise modeling results for the 24-hour cumulative SEL that incorporate noise from the air gun array, profiler, and echosounder.

Table 4.4-14 Level A Take Estimates for Project

Species	Residual PBR	Injury SEL	NMFS Minimum[1] Threshold (Individual Exposure)	NMFS Maximum[2] Threshold (Repeated Exposures)	Ratio: NMFS Maximum/ Minimum[3]
Fin whale[4]	*15*	2.5	0.5	5.2	9.9
Humpback whale[4]	*7.7*	1.2	0.2	2.4	9.9
Blue whale[4]	*2.1*	0.9	0.2	2.0	10.7
Minke whale	2	0.1	<0.1	0.2	9.9
Short-beaked common dolphin	3,376	14.8	36.9	365.2	9.9
Long-beaked common dolphin	151	0.5	1.1	11.2	9.9
Small beaked whale species	25	<0.1	<0.1	0.2	14.1
Harbor porpoise	15	22.8	3.3	35.3	10.7
Dall's porpoise	257	0.9	0.1	1.8	14.1
Pacific white-sided dolphin	178	1.6	3.9	38.7	9.9
Risso's dolphin	39	0.7	1.7	16.7	9.9
Northern right whale dolphin	43.2	0.6	1.3	18.8	14.1
Bottlenose dolphin – CA coastal	2.4	<0.1	0.6	2.7	4.4
Sperm whale[4]	*1.5*	<0.1	<0.1	0.3	14.1
Harbor seal	1,569	7.8	1.7	5.6	3.3
California sea lion	8,766	501.0	109.9	361.7	3.3

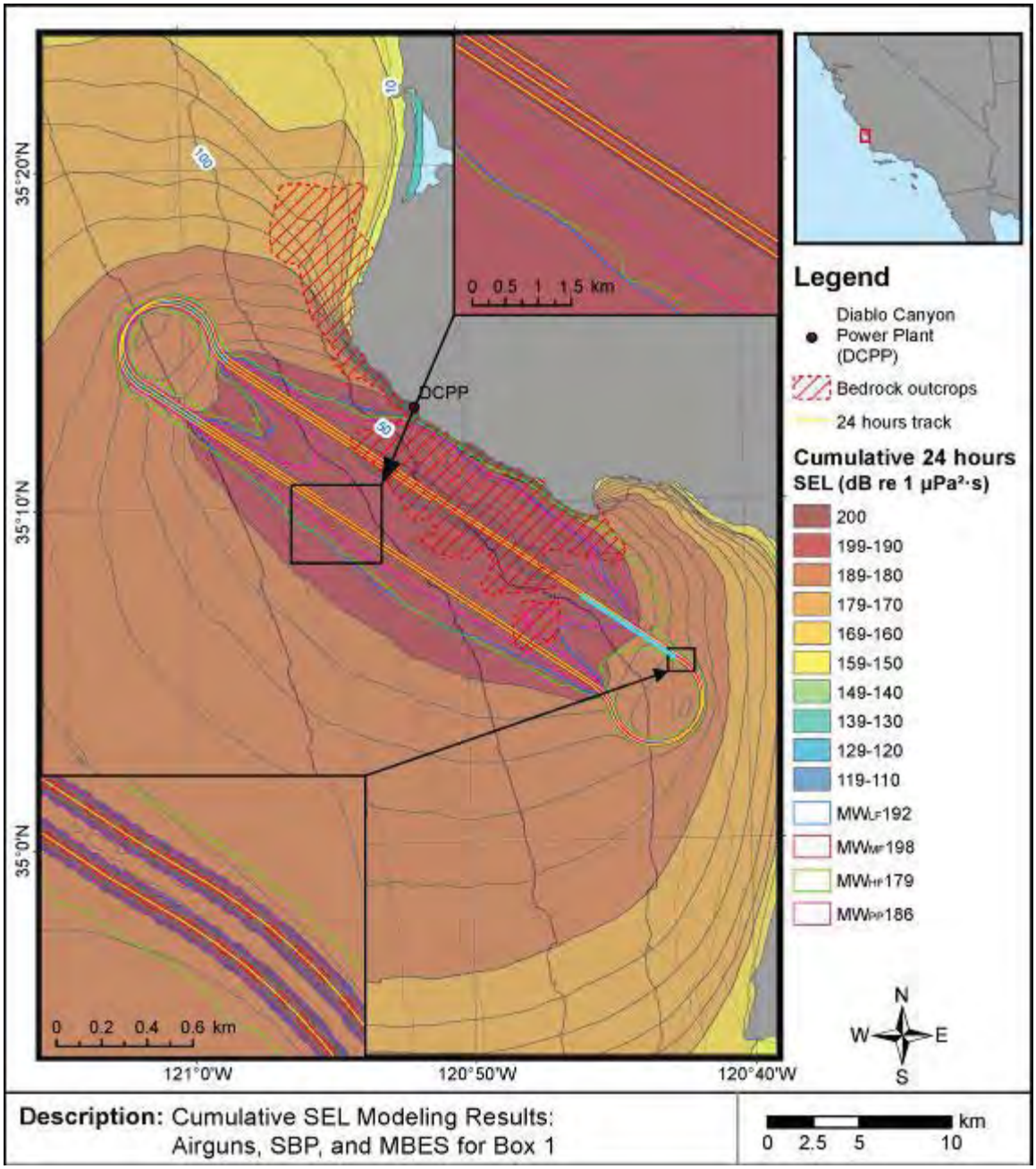
COLOR KEY: Level of Magnitude as percent of PBR

Red – Major (100%) | Orange – Moderate (50-99%) | Yellow – Minor (10-49%) | No color – negligible (<10%)

[1] Area ensonified excluding overlap in acoustic radii; represents the minimum number of takes of animals.
[2] Area ensonified including the overlap in acoustic radii; represents potential multiple takes of animals.
[3] The ratio NMFS Maximum/Minimum quantifies the "intensity" of the survey within the Project footprint related to multiple exposures.
[4] Listed as endangered under the ESA (in *italics*).

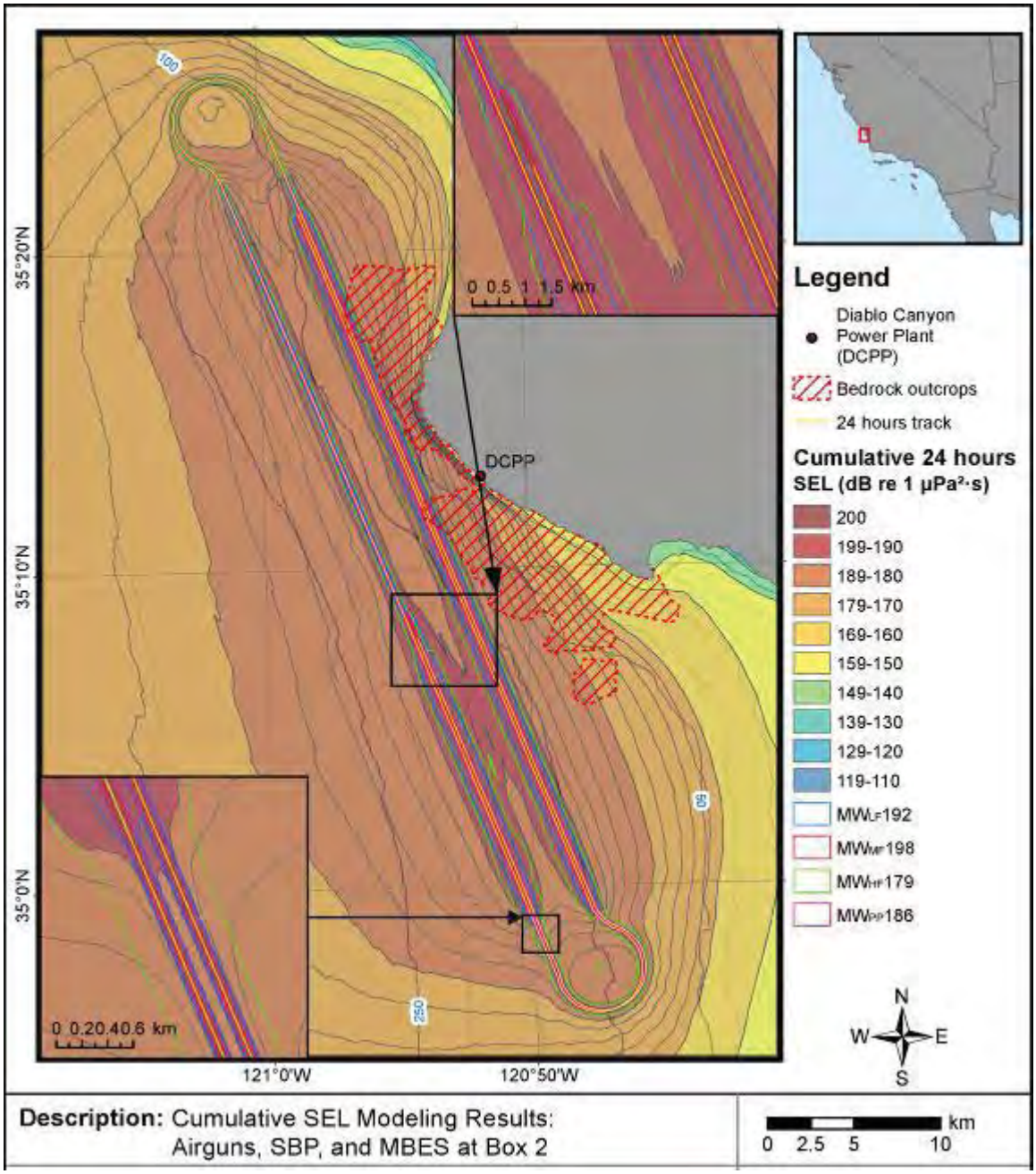
Note: Take estimates have been modified to account for group-specific behavioral avoidance responses (90-99%) whereby animals avoid the area ensonified to the Level A threshold.

Figure 4.4-4 Cumulative (24-hour) SEL Modeling Results – Survey Box 1



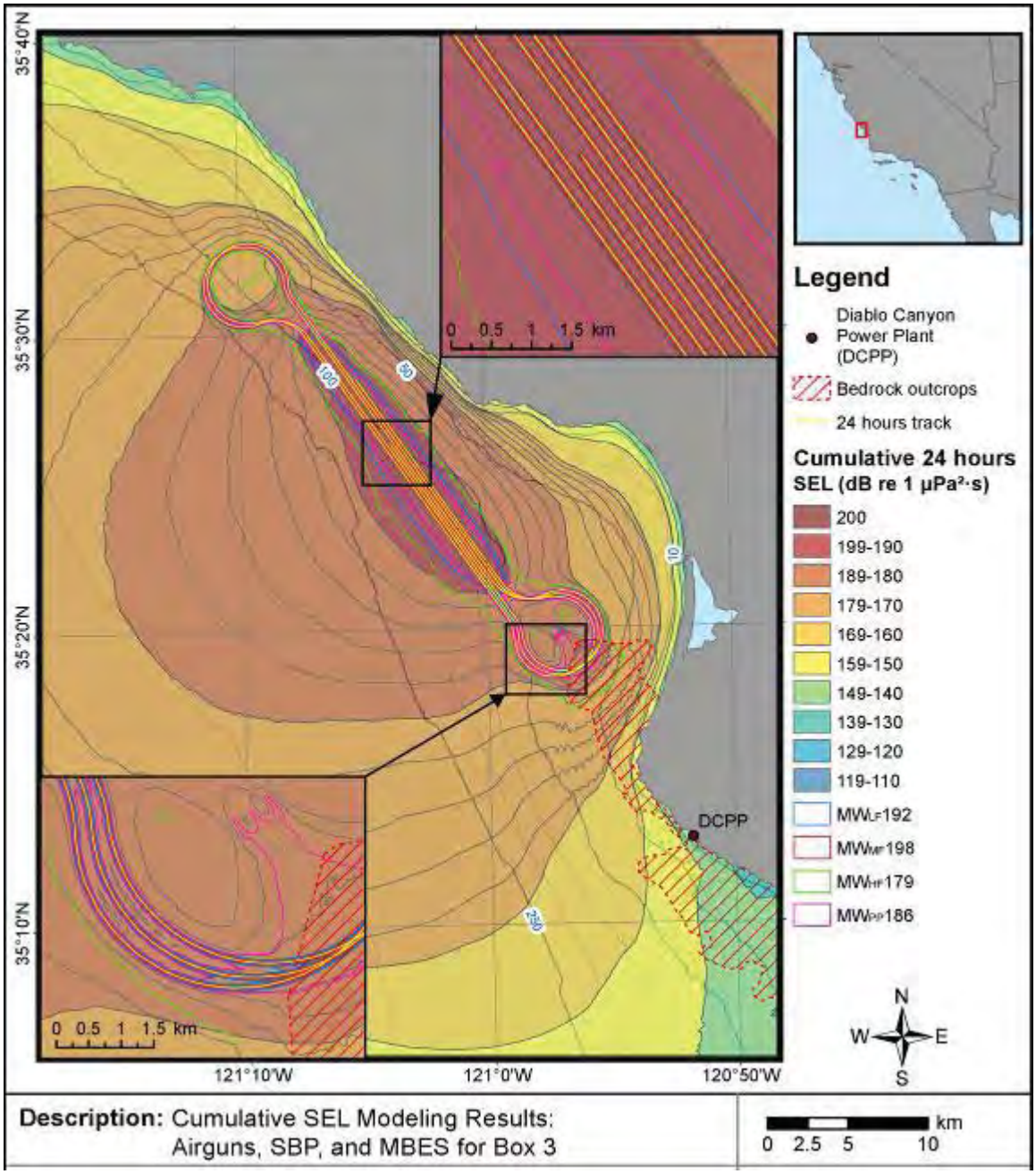
Source: JASCO Applied Sciences 2012.

Figure 4.4-5 Cumulative (24-hour) SEL Modeling Results – Survey Box 2



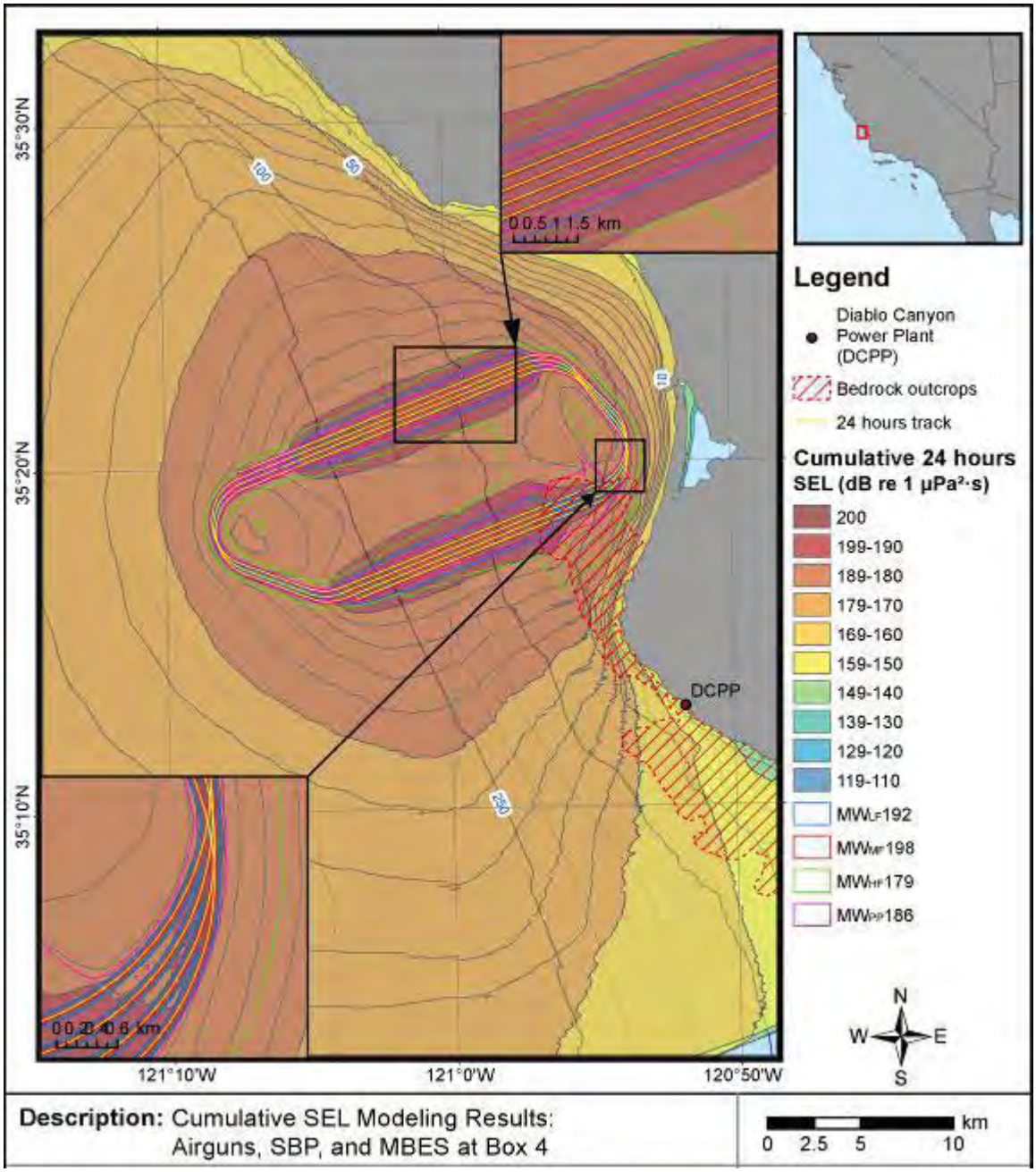
Source: JASCO Applied Sciences 2012.

Figure 4.4-6 Cumulative (24-hour) SEL Modeling Results – Survey Box 3



Source: JASCO Applied Sciences 2012.

Figure 4.4-7 Cumulative (24-hour) SEL Modeling Results – Box 4



Source: JASCO Applied Sciences 2012.

Overview of Level B Acoustic Take Estimates

Level B acoustic takes were calculated using two different sets of thresholds, as described earlier in this subsection (see Tables 4.4-10 and 4.4-12).

Level B acoustic take estimates were calculated for the *Probabilistic Disturbance rms* thresholds (details provided in Table 4.4-15); these represent estimates of the minimum number of individual takes. Results are also shown for NMFS Level B thresholds representing the *Minimum*, as well as *Maximum* takes, which consider the entire area ensonified including all areas of overlap (excluding Level A areas). This metric provides an indication of the potential for multiple takes of the same individual.

Similar to the calculations for Level A take, three density scenarios have been modeled (Base, Upper, and Potential) and results have been calculated to reflect species-specific water depth cut-off criteria and depth-dependent density variability (for harbor porpoise). The Base scenario is shown in Table 4.4-15. Appendix H contains estimates for all three scenarios.

Figure 4.4-8 shows the area within the NMFS Level B threshold contour, accounting for noise from the air gun array, profiler, and echosounder.

Table 4.4-15 Level B Take Estimates for Project

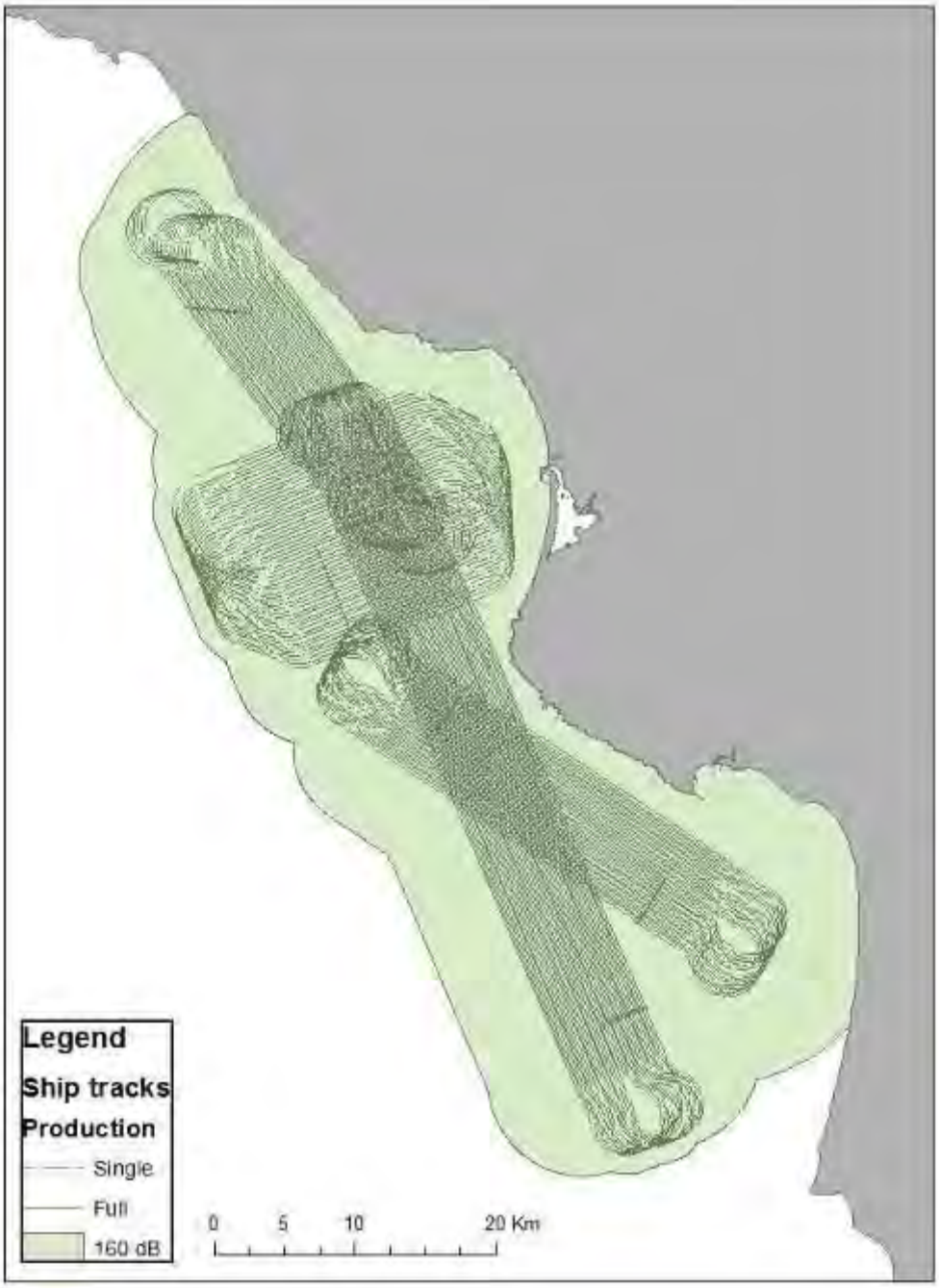
Species	Minimum Population estimate[1]	Probabilistic Disturbance[2] (rms m-Weighted)	NMFS Minimum[2,3] (Individual Exposure)	NMFS Maximum[4] (Repeated Exposures)	Ratio: NMFS Maximum/ Minimum[5]
Fin whale[6]	*2,624*	77.6	14.4	484.4	33.7
Humpback whale[6]	*1,878*	36.5	6.8	227.7	33.7
Blue whale[6]	*2,046*	38.3	4.8	137.1	28.6
Minke whale	202	2.5	0.5	15.3	33.7
Short-beaked common dolphin	343,990	1,047.1	1,012.1	34,116.8	33.7
Long-beaked common dolphin	17,127	32.2	31.1	1,049.9	33.7
Small beaked whale species	2,498	50.9	2.9	61.9	21.6
Harbor porpoise	1,478	1,438.6	734.1	19,379.5	26.4
Dall's porpoise	32,106	270.4	26.8	577.1	21.6
Pacific white-sided dolphin	21,406	111.0	107.3	3,616.6	33.7
Risso's dolphin	4,913	47.8	46.2	1,557.5	33.7
Northern right whale dolphin	6,019	44.3	35.6	784.0	22.0
Bottlenose dolphin – CA coastal	290	19.8	41.4	1,838.4	44.4
Sperm whale[6]	*751*	0.8	0.6	13.3	22.0
Harbor seal	26,667	48.7	38.8	1,279.8	33.0
California sea lion	153,337	3,137.4	2,496.0	82,392.8	33.0

COLOR KEY: Level of Magnitude as percent of Minimum Population Estimate.

Red – Major | Orange – Moderate | Yellow – Minor | No color – negligible

Notes:
[1] See Table 4.4-7 for explanation of population estimates.
[2] Based on a percentage of the minimum population estimate, red indicates high magnitude (Listed species >2.5%, non-listed species >25%), orange indicates moderate magnitude (Listed species 1.25-2.5%, non-listed species >15-25%), yellow indicates low magnitude (Listed species >1 individual, non-listed species 5-15%) and no color is negligible.
[3] Area ensonified without any overlap in acoustic radii; represents the minimum number of takes of animals.
[4] Area ensonified including the overlap in acoustic radii; represents potential multiple takes of animals.
[5] The ratio NMFS Maximum/Minimum quantifies the "intensity" of the survey within the Project footprint.
[6] Species listed as endangered under the ESA (in *italics*).

Figure 4.4-8 Ensonified Area: NMFS Level B Threshold (All Noise Sources)



Source: Sea Mammal Research Unit Ltd. 2012 and JASCO Applied Sciences 2012.

Summary of Acoustic Take Results

The analysis of impacts on marine mammals focuses on the 16 species considered to be at risk of potential effects. As summarized above, the approach used in this analysis provides a range of take numbers for each species (except sea otters) potentially affected and is precautionary in the assessment in four notable ways:

- Range of Density Estimates – Densities of marine mammal populations within the Project area have been provided as a range (Base, Upper, and Potential) in order to reflect the variability in local density and the difference between the scale of the population model and the Project area, as well as the challenges associated with predicting seasonal or annual variability. This discussion uses the "Base" density scenario. See Appendix H for full discussion.
- Level A take is considered the equivalent of a biological removal (whether indirectly or directly through loss of foraging success or decreased reproductive success) and are compared to PBR as a metric for assessing the relevance of potential mortality at the population level.
- Level B take has been assessed using two criteria:
    - The potential for multiple takes is represented by the NMFS *Maximum* results and is likely an overestimate of take. However, this overestimate provides a worst-case scenario for evaluating the potential impacts to animals affected.
    - Applying the *Probabilistic Disturbance rms* criteria for behavioral disturbance ranging from 120 to 180 dB re 1 µPa (rms – m-weighted), which considers the increased sensitivity of certain species (i.e., harbor porpoises and mysticetes) to noise disturbance. The current NMFS threshold for behavioral response for all marine mammals is 160 dB re 1 µPa (rms, un-weighted).

Project Level A takes and resulting magnitude ratings were consistently higher for *Injury SEL* Level A for fin, humpback, and blue whales, as well as harbor porpoise, compared to NMFS *Minimum* takes. NMFS *Minimum* takes were higher for mid-frequency cetaceans (Table 4.4-16). For the Project, when considering the APMs, additional proposed MMs, and under the assumed 99 percent avoidance response, harbor porpoise exceeded the high magnitude criteria for Level A (>100 percent of residual PBR) for *Injury SEL* at all density scenarios, but remained at low magnitude using NMFS *Minimum* criteria. Under the assumed 90 percent avoidance responses, both humpback and blue whale takes exceeded the high magnitude criteria for *Injury SEL* at the Potential density scenario.

Project Level B *Probabilistic Disturbance* rms takes and resulting magnitude levels were considerably higher than NMFS *Minimum* takes for endangered mysticete; however, both methods resulted in high magnitudes for harbor porpoises (Table 4.4-17). Project

Level B take estimates for NMFS *Minimum* methods also exceeded high magnitude criteria for Level B for harbor porpoise under all density scenarios (ranging between 50 and greater than 100 percent of the population).

Acoustic Effects of Echosounder and Sub-bottom Profiler

In addition to noise from the air guns, sounds from the echosounder may contribute to Level A and Level B take of marine species. Sounds from the echosounder would include very short pings, occurring for 2 to 15 milliseconds once every 5 to 20 seconds, depending on water depth. Most of the energy in the sound emitted by the echosounder is at frequencies near 12 kilohertz (kHz), and the maximum source level is 242 dB re 1 μPa rms. Due to the narrow foreaft width of the beam (1 degree) and the brevity of the ping, it is unlikely that marine mammals would be exposed to more than one ping. Kremser et al. (2005) noted that the probability of a cetacean swimming through the area of exposure when an echosounder emits a ping is small.

Sounds from the profiler would be short pulses, occurring at 1 second intervals; a common mode of operation is to broadcast five pulses at 1-second intervals, followed by a 5-second pause, with the beam directed downward. Kremser et al. (2005) noted that the probability of a cetacean swimming through the area of exposure when a profiler emits a pulse is small. Nevertheless, the combination of noise from the air guns, echosounder, and sub-bottom profiler could potentially result in direct and indirect effects on marine species by causing disturbance (avoidance behavior) or effects on prey availability.

In general, the echosounder was loudest at close distances, with the single air gun becoming relatively louder at greater distances. This is due to the louder source level of the echosounder and higher frequency content (12 kHz) compared to the single air gun (most energy less than 1 kHz). Frequency dependent absorption increases with frequency such that the echosounder sound is attenuated at a faster rate than the single air gun. Therefore, at a certain distance, the single air gun sound becomes relatively louder than the echosounder even though the echosounder started out louder at the source. Under certain depth scenarios and frequency weighting (HFC and pinnipeds in water), the profiler was louder than the single air gun or echosounder. This is likely due to the wide frequencies used by the profiler (3.5, 12, 200 kHz).

Acoustic impacts for Level A take of combined active sources including the air guns, echosounder, and profiler resulted in high impact ratings for harbor porpoise under all density scenarios using the *Injury SEL* criteria. This indicates that harbor porpoises are likely to be significantly impacted by the combination of the three sound sources, regardless of the density scenario, whereas impacts to blue and humpback whales could occur only under the high density scenario. Please see Appendix H – Marine Mammal Technical Report.

As described in Appendix H – Marine Mammal Technical Report, Level B take for acoustic impacts of combined sources (air guns, echosounder, and profiler) was considered high under all density scenarios for harbor porpoise, fin whales, humpback whales, and blue whales using the *Probabilistic Disturbance* rms criteria. High impacts were also indicated using the NMFS *Minimum* Level B criteria for harbor porpoise (all density scenarios). In other words, when all acoustic noise sources are combined, Level B take would be likely to result in high impacts to harbor porpoise regardless of the density scenario and impacts to fin, humpback, and blue whales, and bottlenose dolphins could occur assuming higher animal densities than the Base case.

Noise-related Impacts on Gray Whales (Less than Significant)

The Project area co-occurs with the migration route for majority of Eastern North Pacific Stock of gray whales, a population numbering up to 19,126. Southward transit through Project area is estimated to start mid-December (15th) and peaks mid-January (15th). Small numbers may migrate through the area prior to the predicted start of migration. The majority of the population is likely to travel within a few nm of the coast and pass through the Project area in less than 24 hours, with limited feeding expected to take place.

Based on likely sensitivity and (somewhat limited) use of low-frequency sounds, gray whales may be more likely than odontocete cetaceans to be affected by seismic noise. Gray whales have exhibited localized avoidance of seismic exploration sound (Malme et al. 1984). However, there is no strong evidence suggesting gray whales are particularly sensitive to seismic or other low-frequency noises. Thus, gray whales are expected to exhibit temporary avoidance behavior of the seismic survey.

Assuming the survey were completed prior to mid-December, Project impacts would likely be *Less than Significant* when considering APM-1 through -8, including survey timing (APM-1), project-specific Exclusion Zone (APM-2 and -3), air gun ramp-up (APM-4), continual air gun firing during transit (APM-5), aerial surveys (APM-6), and MMOs (APM-7). However, this conclusion is dependent on the timing of the survey. If the survey were to continue past December 15, potential impacts could occur. If the survey were delayed beyond January 2, significant adverse effects could result as Level B takes could reach medium magnitude by January 2 (15 percent or 2,703 whales) and high magnitude after January 6 (25 percent or 4,504 whales).

Potential Level A takes are highly unlikely to exceed residual PBR of 233 animals given the responses to noise and typical inshore migration patterns. In addition to APM-1 through -8, special mitigation monitoring would be recommended if the survey were delayed beyond December 15, to confirm non-blocking avoidance reaction and to study patterns of migration timing and rate to minimize potential impacts. Overall, based on

the assumption that the seismic survey would be completed prior to mid-December, potential noise-related Project impacts on gray whales would be *Less than Significant* for gray whales.

Summary of Noise-related Impacts on Marine Mammals

As summarized above, Level A and Level B harassment, using NMFS, Injury SEL and Probabilistic Disturbance criteria, would result in acoustic takes for a number of species/species groups due to noise from the proposed survey actvities. APM-1 through -8 would reduce the potential for adverse noise impacts to marine mammals, yet the impact is expected to be substantial. In order to improve upon the protective measures included in the APMs, the following mitigation measures shall be implemented.

MM MARINEBIO-12a Expand Pre-Survey to 8.6 Miles (14 Kilometers) and Perform 10 Days in Advance of Survey. Pacific Gas & Electric Company (PG&E) shall conduct a pre-survey of the Project area and vicinity to 8.6 miles (14 kilometers) (twice the maximum 160-decibel re 1 μPa root mean square isopleth) for mysticetes (baleen whales), approximately 10 days prior to the start of the survey to allow for analysis of data obtained during the pre-survey and to make adjustments to the survey schedule as needed. For this mitigation measure, PG&E shall conduct a sighting survey to specifically assess and record mysticete density and the location of all major marine mammal concentrations. Based on the results of the pre-survey, PG&E shall develop an approach for the seismic survey to reduce potential impacts to marine mammals, such as proceeding with the survey Zone with the lowest mammal density or delaying the survey until non-critical densities of marine mammals are detected.

Survey Approach:

- Use protocols established for aerial surveys by the National Atmospheric and Oceanic Administration (NOAA, e.g., Forney et al. 1995), with line spacing of the aerial surveys modified to maximize coverage in the pre-survey area. Surveys shall only be carried out in suitable conditions (e.g., Beaufort 4 and below, good visibility).

Analysis of Pre-survey Data:

- Assess mysticete densities in the pre-survey area in comparison to Environmental Impact Report assumptions and thresholds. The following densities correspond to high magnitude Level B take estimates for Endangered Species Act (ESA) listed baleen whales:

ESA-Listed Mysticete Species	Density Threshold Predicted to Result in High Magnitude Intensity Rating (per km^2)	Number of Animals within Estimated Aerial Survey Area of 3,074 km^2
Fin Whale	0.0073	23
Blue Whale	0.0063	19
Humpback Whale	0.0053	16

Assumptions:
1. Densities correspond to 2.5 percent threshold for probabilistic Level B noise disturbance over duration of Project.
2. Pre-survey aerial survey area based on 14-kilometer buffer proposed in this mitigation.

- Identify locations of sightings of porpoise and large concentrations of mammals.

Actions:

- Report pre-survey findings to the California State Lands Commission and the National Marine Fisheries Service as soon as feasible, but at least two days prior to beginning the survey.
- If the density of animals in the aerial survey area exceed the values noted above PG&E shall consult with the California State Lands Commission and the National Marine Fisheries Service about potential strategies to avoid conducting the survey in areas with higher concentrations of these mysticete species.
- Prioritize survey areas to avoid large concentrations of mysticetes and harbor porpoise.

As specified in APM-6, aerial surveys would be performed prior to survey initiation, during the initial stages of the survey, and 1 week prior to survey completion. The APM states that aerial surveys would extend for a longer period, if needed, but it is unclear how the need for extended surveys would be ascertained. The aerial surveys would provide valuable information regarding long-range mammal migration rates and routes that would supplement MMO observations onboard the vessels. Therefore, the following MM would be implemented to augment APM-6.

MM MARINEBIO-12b Extend Aerial Surveys Throughout Survey Period. Pacific Gas & Electric Company shall conduct ~~weekly~~aerial surveys of the Project area and vicinity one week prior to initiating survey activities in each survey zone, The aerial surveys shall cover the area out to approximately 8.6 miles (14 kilometers), twice the maximum 160-decibel re 1 μPa root mean square isopleth for mysticetes, to determine whether large concentrations of mysticetes were occurring within the larger ensonified area or other zones to be surveyed. High concentrations would lead to survey operation modifications as per MM MARINEBIO-12a.

The following MM would be implemented to avoid potential impacts to pinniped haul-outs by aerial surveys.

MM MARINEBIO-12c Avoidance of Pinniped Haul-Outs. Pacific Gas & Electric Company shall establish a flight plan for the aerial surveys that includes plans to avoid local pinniped haul-outs or to maintain sufficient altitude (greater than 500 feet [152 meters] above sea level) when passing local pinniped haul-outs.

As specified in APM-7, marine mammal monitoring would be performed by qualified MMOs during daylight survey operations; however, the APM does not provide specifics regarding the nature of their qualifications or the manner in which they would conduct monitoring activities. The APM excludes nighttime monitoring, but marine wildlife may be present near survey vessels at night and could be at risk for ship strike. With the proper equipment, it would be possible to monitor for marine mammals during nighttime. To enhance the quality and effectiveness of the MMO activities, the following MM would be implemented.

MM MARINEBIO-12d Required Marine Mammal Observer Qualifications, Use of Equipment and Procedures to Enhance Detection Rates, and Performance of Nighttime Monitoring. This mitigation measure expands upon the monitoring activities identified under APM-7. The Marine Mammal Observers (MMOs) used for the Project shall be independent and demonstrated to have had considerable experience sighting local species and using Passive Acoustic Monitoring. Appropriate equipment/procedures shall be used to improve daytime detection rates (including big-eye binoculars, sufficient numbers of MMOs, and required rest periods). Monitoring shall be performed during the nighttime using Passive Acoustic Monitoring that may be supplemented by equipment to enhance night detection rates (including advanced infrared equipment, sodium lighting, and/or millimeter waves radar). There shall be a minimum of three MMOs assigned to each vessel (survey vessel and two scout boats), with two MMOs on watch at a time. The third would rest and then rotate with other MMOs to enhance vigilance during watch times.

The following MM would be implemented to augment APM-2.

MM MARINEBIO-12e Increase Size of Exclusion Zone During Surveys. Pacific Gas & Electric Company shall increase the size of the Exclusion Zone for the full air gun array to ~~1.2~~1.1 nautical miles (2 kilometers) for baleen whales (mysticetes), whose hearing sensitivity overlaps the greatest with seismic air gun signals; sperm whales; and large groups of marine mammals (i.e., porpoises).

Responses to such observations shall be as described under APM-7 (reduce speed to avoid).

Exclusion Zones for array power-down and the single mitigation air gun shall be estimated from sound measurements conducted during air gun deployment (APM-3), and shall include real-time measurements over at least one area of rocky seabed. PG&E shall submit results of the real-time measurements and recommended power-down and mitigation gun Exclusion Zones based on the real-time measurements. This information shall be submitted to the California State Lands Commission and National Marine Fisheries Service for review and approval prior to the survey.

APM-7 specifies that a single scout vessel with qualified MMOs would traverse the Exclusion Zone during the surveys. Because of the large size of the survey area, and the potential that it could become necessary to alter course to avoid marine wildlife, a single scout vessel might not be sufficient to observe marine mammals migrating into the path of the survey vessel. This could result in an increased potential for ship strikes. To reduce this potential, the following MM would be implemented.

MM MARINEBIO-12f Monitoring Using Two Scout Boats with Marine Mammal Observers During Surveys. A total of two scout boats with MMOs shall be used to increase detection rates within the Exclusion Zone. These boats shall maintain a distance of half the Exclusion Zone on either side of the survey vessel. While surveying near shore, these scout boats shall ~~re-orient to maintain a minimum 1.2-mile (2-kilometer) distance from shore~~remain outside of surface kelp area to avoid additional otter disturbance.

While there may be concern that additional scout vessels could increase the risk of ship strikes, the likelihood of this occurring would be low considering the low speed of these vessels. In addition, the benefit of increasing the detection rate of MMOs would outweigh the potential risk of a ship strike.

As specified in APM-8, PAM would be employed by MMOs during daylight and nighttime hours to reduce the potential for ship strikes to marine mammals. Monitoring by MMOs would not be as effective during nighttime hours due to limited visibility. Many resident species will have high densities in inshore areas (including harbor porpoise, sea otters, bottlenose dolphins, and harbor seals). In addition, Church Rock appears to be a hotspot for humpback whales and other cetaceans. Therefore, because of the increased density of marine mammals in these areas, the proposed surveys would be conducted during daylight hours to increase detection success by MMOs. The following MM would be implemented to reduce the potential for nighttime ship strikes.

MM MARINEBIO-12g Perform Track Lines with Highest Mammal Densities During Daylight Hours. To the extent feasible, Pacific Gas & Electric Company shall perform the inshore tracks of the seismic survey to coincide with daylight hours. In addition, Pacific Gas & Electric Company shall conduct surveys near Church Rock (North 35º 20.675 West 120º 59.049) during daylight hours to the extent possible.

The following MMs shall be implemented to reduce noise impacts, and broadly apply to all species/species groups expected to be present in the Project area.

MM MARINEBIO-12h Increase Pre-Ramp-Up Scan Period. As a modification to APM-4, Pacific Gas & Electric Company shall increase the pre-ramp-up scan period to 45 minutes, especially in poor sighting conditions. Some species have long dive times and only spend short periods of time at the surface between dives. Other species are hard to spot at long range or in poor conditions. Increasing the pre-ramp-up scan period will increase the chance of sighting these individuals. Also, Pacific Gas & Electric Company shall increase the time for observation in the Exclusion Zone following power-down or shutdown.

MM MARINEBIO-12i Adaptive Management in Case of Multiple Shutdowns. If ~~M~~more than three shutdowns occur for mysticete whales observed in the Exclusion Zone, PG&E shall ~~result in~~ initiate an immediate project review in consultation with the California State Lands Commission and the National Marine Fisheries Service to assess the safety of Project area conditions. The two agencies shall be notified within 24 hours of the fourth consecutive shutdown. Aerial survey data and observations noted by the Marine Mammal Observers shall be provided to the noted agencies for review and consideration of potential refinements required in mitigation strategy. The survey activity may proceed while the agencies assess the situation, unless otherwise directed by the California State Lands Commission.

MM MARINEBIO-12j Contingency for Sighting of North Pacific Right Whale. PG&E shall shut down air guns if a North Pacific right whale is sighted at any distance from the survey vessel.

"Take" and "Harassment" Under the MMPA

Take

As defined under the MMPA, to "harass, hunt, capture, kill or collect, or attempt to harass, hunt, capture, kill or collect."

Harassment

Harassment is defined under the MMPA as any act of pursuit, torment, or annoyance that:

- ***(Level A Harassment)*** has the potential to injure a marine mammal or marine mammal stock in the wild; or,
- ***(Level B Harassment)*** has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.

This assessment employed a number of techniques to analyze the expected noise levels and exposure resulting from the Project, and the effects those conditions may have on marine mammals. The following tables of Level A and Level B Take Estimates provide the estimates of the numbers of individuals, by species, that would be affected. The analysis also attempts to put those estimates into the context of the vulnerability of each species owing to its population size, density expected during the survey, and sensitivity to the frequency that would be generated by the air guns and other noise sources.

Table 4.4-16~~8~~ summarizes Level A and Level B take estimates for all marine mammals (except the gray whale and sea otter, which are discussed separately) and significance based on CEQA criteria established for this analysis. The CEQA significance criteria are applied to each species. For special status species, a single take is considered to be significant in this analysis. Substantial interference in the movement of any native resident, such as the Morro Bay stock of the harbor porpoise, is also considered to be significant. For species that do not have special status, this analysis considered the magnitude of the effect estimated for each species. The significance levels presented in Table 4.4-16~~8~~ represent the best estimate of the effects on each species, as well as the significance of these effects in the context of this EIR. However, while impacts to certain individual species are expected to be below the threshold of significance established for this analysis, as stated above in Impact MARINEBIO-12, the overall potential noise-related Project impacts on marine mammals are considered to be *Significant and Unavoidable.*

Table 4.4-168 Summary of Take Estimates for Project

Species	Level A[1]		Level B[2]		CEQA Impact[3]	Noise-related Impacts
	Injury SEL	NMFS Minimum Threshold Individual Exposure	Probabilistic Disturbance (rms m-Weighted)	NMFS Minimum Individual Exposure		
Fin whale[4]	2.5	0.5	77.6	14.4	SU	• Likely to exhibit temporary, localized avoidance behavior during noise exposure (based on responses of gray and humpback whales) • Density may vary annually, depending on the availability of suitable prey • Reduced availability of prey resources due to noise disturbance and/or avoidance reactions during and for a short period after the survey • Expenditure of additional energy to reach other foraging locations and potentially compete with other species for these resources
Humpback whale[4]	1.2	0.2	36.5	6.8	SU	• Variable responses to seismic noise (limited local avoidance, attraction to seismic pulses among males) • Low-frequency hearing sensitivity (assumed) • Target both krill and forage fish (notably sardine and anchovy) that fluctuate seasonally and geographically • Reduced availability of prey resources due to noise disturbance and/or avoidance reactions during and for a short period after the survey • Expenditure of additional energy to reach other foraging locations and potentially compete with other species for these resources
Blue whale[4]	0.9	0.2	38.3	4.8	SU	• Likely to exhibit temporary, localized avoidance behavior during noise exposure (based on responses of gray and humpback whales) • Low-frequency hearing sensitivity (assumed) • Feed primarily on krill and prefer local waters deeper than 262.5 feet (80 m), with preference for waters

Species	Level A[1]		Level B[2]		CEQA Impact[3]	Noise-related Impacts
	Injury SEL	NMFS Minimum Threshold Individual Exposure	Probabilistic Disturbance (rms m-Weighted)	NMFS Minimum Individual Exposure		
						approximately 656 feet (200 m) deep • Reduced availability of prey resources due to noise disturbance and/or avoidance reactions during and for a short period after the survey • Expenditure of additional energy to reach other foraging locations and potentially compete with other species for these resources
Minke whale	0.1	<0.1	2.5	0.5	LTS	• Low-frequency hearing sensitivity (assumed) • No clear evidence that the Project area provides particularly valuable habitat for minke whales
Short-beaked common dolphin	14.8	36.9	1047.1	1012.1	LTS	• Likely to exhibit localized and temporary avoidance behavior over a limited range, depending on the behavioral state (based on responses of other odontocetes) • Confirmed multiple occurrences of common dolphins entering Exclusion Zones of seismic surveys • Mid-frequency hearing sensitivity • Very abundant and range widely, with optimal habitat considered seaward of 656 feet (200 m) • Prey upon a variety of fish and cephalopod species and are consequently considered generalist feeders, with flexible foraging strategy
Long-beaked common dolphin	0.5	1.1	32.2	31.1	LTS	• Likely to exhibit localized and temporary avoidance behavior over a limited range, depending on the behavioral state of animals during exposure (based on responses of other odontocetes) • Mid-frequency hearing sensitivity • Very abundant and range widely, with optimal habitat considered seaward of 656 feet (200 m) • Prey upon a variety of fish and cephalopod species and

Species	Level A[1]		Level B[2]		CEQA Impact[3]	Noise-related Impacts
	Injury SEL	NMFS Minimum Threshold Individual Exposure	Probabilistic Disturbance (rms m-Weighted)	NMFS Minimum Individual Exposure		
						are consequently considered generalist feeders, with flexible foraging strategy
Small beaked whale species	<0.1	<0.1	50.9	2.9	LTS	• Apparent sensitivity to sounds of various types (possibly a function of their social and group configurations) • Likely be a greater potential for avoidance behavior at greater ranges • Multiple narrow canyons located approximately 30 nm (55.5 km) south of the Project area (off Vandenberg) are considered potential valuable habitat, but neither the 140 nor 120 dB isopleths co-occur with this area • Habitat within or near the Project area is not considered important for beaked whales
Harbor porpoise	22.8	3.3	1438.6	734.1	SU	• Apparent sensitivity to sounds of various types would likely result in avoidance behavior • Greater potential for avoidance behavior at large ranges • Avoidance of important habitat at may still occur • Individual animals may be exposed up to 26 times over the course of the survey • Population is resident species, and high-density within Project area • Likelihood of impacts resulting from individual and prey disturbance due to acoustic stress would be high • Project would cause significant interference in porpoise movement and result in an adverse effect due to a reduction in core habitat
Dall's porpoise	0.9	0.1	270.4	26.8	LTS	• Considered wide-ranging, flexible in foraging strategy • Prefer deep ocean habitat
Pacific white-sided	1.6	3.9	111.0	107.3	LTS	• Mid-frequency hearing sensitivity • Localized and temporary avoidance behavior could

Species	Level A[1]		Level B[2]		CEQA Impact[3]	Noise-related Impacts
	Injury SEL	NMFS Minimum Threshold Individual Exposure	Probabilistic Disturbance (rms m-Weighted)	NMFS Minimum Individual Exposure		
dolphin						occur, depending on behavioral state during exposure (based on responses from other odontocetes) • Considered wide-ranging, flexible in foraging strategy • Prefer deeper habitat
Risso's dolphin	0.7	1.7	47.8	46.2	LTS	• Localized and temporary avoidance behavior could occur, depending on behavioral state during exposure (based on responses from other odontocetes) • Considered wide-ranging, with a selective foraging strategy
Northern right whale dolphin	0.6	1.3	44.3	35.6	LTS	• Localized and temporary avoidance behavior could occur, depending on behavioral state during exposure (based on responses from other odontocetes) • Considered wide-ranging • Prefer deeper habitat than would be found in the Project area
Bottlenose dolphin – CA coastal	<0.1	0.6	19.8	41.4	LTS	• Mid-frequency hearing sensitivity • Localized and temporary avoidance behavior could occur, depending on behavioral state during exposure (based on responses from other odontocetes) • High densities not expected unless local warm water incursion were to occur during survey period
Sperm whale[4]	<0.1	<0.1	0.8	0.6	LTS	• Measured responses to low air gun noise indicate minor changes in foraging behavior; responses at moderate to higher levels of air gun noise have not been measured • Mid-frequency hearing sensitivity • Localized and temporary avoidance behavior could occur, depending on behavioral state during exposure (based on responses from other odontocetes) • Prefer deep offshore water; chances of appearing within

Species	Level A[1]		Level B[2]		CEQA Impact[3]	Noise-related Impacts
	Injury SEL	NMFS Minimum Threshold Individual Exposure	Probabilistic Disturbance (rms m-Weighted)	NMFS Minimum Individual Exposure		
						or near the Project area would be remote • Project area not considered optimal habitat
Harbor seal	7.8	1.7	48.7	38.8	LTS	• Localized and temporary avoidance behavior could be exhibited (based on responses of other pinnipeds) • Response may only occur over limited range, and would likely depend on behavioral state during exposure • Up to 33 repeated exposures of individual animals could occur during survey if animals did not leave area • Considered abundant and widely distributed • Local resident population has a strong preference for near-shore areas
California sea lion	501.0	109.9	3,137.4	2,496.0	LTS	• Localized and temporary avoidance behavior could be exhibited (based on responses of other pinnipeds) • Response may only occur over limited range, and would likely depend on behavioral state during exposure • Considered very abundant and widely distributed, with very flexible foraging strategy

COLOR KEY: Level of Magnitude (see Notes below)

Red – Major | Orange – Moderate | Yellow – Minor | No color – negligible

Notes:
[1] Based on a magnitude as a percentage of PBR, red indicates major magnitude (100% PBR), orange indicates moderate magnitude (50-99% PBR), yellow indicates minor magnitude (10-49% PBR), and no color is negligible. [2] Based on a percentage of the minimum population estimate, red indicates high magnitude (Listed species >2.5%, non-listed species >25%), orange indicates moderate magnitude (Listed species 1.25-2.5%, non-listed species >15-25%), yellow indicates low magnitude (Listed species >1 individual, non-listed species 5-15%) and no color is negligible.
[3] Significance based on CEQA thresholds established for this EIR.
[4] Species listed as endangered under the ESA (in *italics*).
SU = Significant and Unavoidable
LTS = Less than Significant

Impact MARINEBIO-13: Injury or mortality to Southern Sea Otters would occur due to noise during seismic survey acquisition. (Significant and Unavoidable)

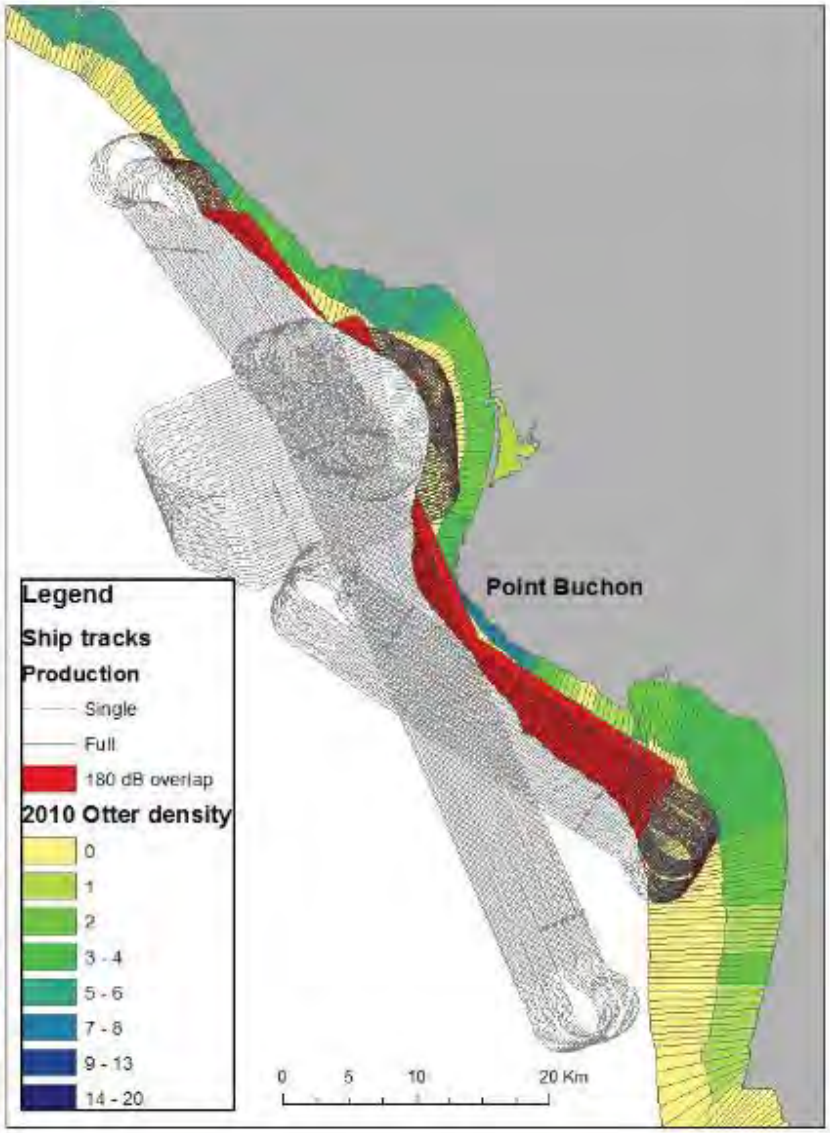
The range for southern sea otters extends from about Half Moon Bay north of the Project area to Santa Barbara in the south. They are resident to the Project area where they inhabit nearshore waters, with the highest density near Point Buchon. In 2010, the coast from San Simeon to Point Sal contained 874 sea otters, approximately 30.5 percent of the total population of this stock. They breed between both June and July and October and November. Sea otters feed primarily on invertebrates and dive depths are typically less than 98 feet (30 m) for females and less than 131 feet (40 m) for males (USGS 2010).

Sea otters appear insensitive to seismic noise (Malme et al. 1984) at ranges greater than 0.6 miles (900 m), but can be disturbed by close approaches from boats. There are limited available data on responses of sea otters to seismic air guns, as well as their hearing abilities, but the ability to raft without immersing their heads and ears would be considered enough to preclude injury from noise.

For this analysis the NMFS Level A threshold for cetaceans (180 dB) was used as the Level B threshold for sea otters. Because sea otters have the ability to avoid immersion of their heads and ears, this Level A noise level was considered to be appropriate for assessing the extent of disturbance (Level B harassment) to Southern sea otters due to noise. ~~n~~Noise modeling results were used to determine the area corresponding to the 180 dB isopleth radius. ~~NMFS Level A threshold, and~~This area was compared ~~this~~ with the expected sea otter density within this area. The ~~NMFS Minimum Level A threshold~~ 180 dB radius overlaps with sea otter habitat (including in the vicinity of Point Buchon); however, much of the overlap is in waters deeper than 98 feet (30 m) (i.e., out of the female and pup core areas). Overall, the overlap area was estimated to contain 62~~1~~ animals (2.2 percent of population).

Assessment of ~~NMFS Level A *Minimum*~~Level B take ~~and~~ regarding boat disturbance to sea otters resulted in values of ~~62~~ 12 and ~~12~~8 individuals, respectively, for the ~~Project~~ survey vessel and geophone line deployments. The boat disturbance estimates during the survey are for one vessel only. If more vessels would be used for mitigation, then the numbers for boat disturbance should be increased proportionate to the number of vessels present and their proximity to sea otter habitat. The majority of takes occurred in Buchon Point vicinity, but overlap with the highest density areas of less than a depth of 98 feet (30 m) in this region were relatively small (Figure 4.4-9).

Figure 4.4-9 Distribution of Overlap of Sea Otter Distribution and ~~NMFS Level A Thresholds~~ 180 dB Isopleth for the Proposed Project



Note: Darker areas represent higher densities of sea otters.
Source: SMRU 2012.

Acoustic impacts would be minimized by APM-1 through -8 and MMs 12a through -i, including survey timing, project-specific Exclusion Zone, air gun ramp-up, aerial surveys, MMOs, and PAM. Although implementation of these measures would reduce the impact to sea otters, and the survey is unlikely to affect pup areas, potential ~~noise-related~~ Project impacts on sea otters ~~are~~ would still result in 82 Level B takes (from noise, survey vessels, and geophone deployment). Therefore, the impact is considered to be *Significant and Unavoidable* because of the proximity of the survey to sea otter habitat.

Cumulative Impact Analysis

Assuming implementation of the APMs and MMs described in more detail in Section 4.4.5 and listed under Impact MARINEBIO-12, the Project would result in significant impacts to fin, humpback, and blue whales; the harbor porpoise; and the Southern sea otter. However, the severity is greatest for the harbor porpoise, even considering the implementation of the APMs and MMs.

The Project area co-occurs with the core habitat of the resident Morro Bay stock of harbor porpoise, a species considered very sensitive to noise effects (Southall et al. 2007). The proposed survey period would be sensitive for this species, as it follows the summer calving period and overlaps with the presumed fall breeding season and calf nursing season. Both *Probabilistic Disturbance rms* and NMFS Level B takes were considered high impact in all six scenarios analyzed (i.e., both methods at all densities). It is likely that individual animals could be exposed up to 26 times over the course of the survey, assuming animals did not leave the Project area. Given that the harbor porpoise population is a resident species, the likelihood of impacts resulting from individual and prey disturbance due to acoustic stress would be high. Overall, the Project would cause significant interference in porpoise movement and result in an adverse effect, primarily due to a reduction in access to core habitat.

As highlighted in Table 4.4-17~~9~~ below, other actions external to the Project but within the area could cumulatively affect harbor porpoise and other marine species.

Table 4.4-17~~9~~ Cumulative Projects Potentially Affecting Marine Species

Project	Brief Description
PG&E Low-Energy 3D Geophysical Surveys	• Data collection and analysis to better characterize fault zones in the vicinity of the DCPP. • Installation of temporary and long-term ocean bottom seismometers to record sound and seafloor movement in the area, placement of a new cable conduit onto the seafloor offshore of Point Buchon, and the extension of an existing conduit to house the power/data cable within the intertidal area of the DCPP intake embayment.
Commercial and Recreational Marine Traffic	• 12,270 registered vessels in San Luis Obispo County in 2010 (12,043 vessels in pleasure category and 114 in commercial category). • Marine traffic is expected to continue well into the future.
Oil Spills and Oil Transport	Fewer than 20 oil spills have occurred in recent years and have been small, often measured in drops. Since 1995, only two oil spills have been more than 1,000 gallons. In 2009, a total of 33.3 billion gallons of oil was transferred through California terminals and only nine spills resulted in a total of 124 gallons spilled (CSLC 2010).
NOAA Permits 14534, 15271, 540-1811, and 781-1824 for Marine Mammal Take	Permits issued to parties conducting research in the vicinity of the Project area; potential incidental harassment of mammals during research activities. Activities vary from aerial surveys to vessel surveys to monitoring foraging and behavioral movements of large whales.

Project	Brief Description
Morro Bay Marina Renovation Project	• Dredge marina to restore navigable capacity, and dispose of a portion of the sediment at a nearshore disposal site; recover any fallen riprap within the dredge footprint and replace it onto the existing marina revetment; and install a new vessel pumpout station on an existing floating dock. • Coastal Development Permit, which is currently pending. Proposed start date of May or June 2012 to begin dredging.
2011 Morro Bay Dredging	• Remove and replace existing docks and piers with pile-guided floating docks and piers that meet American with Disabilities Act requirements; dredge marina basin and entrance channel to a depth of -12 feet Mean Lower Low Water; install steel sheet pile walls along southern and northern shorelines to reduce erosion and sediment deposition into the marina basin. • Coastal Development Permit currently pending. • Proposed start date of May or June 2012.

The low-energy 3D geophysical surveys proposed by PG&E would likely result in moderate effects on harbor porpoises similar to those described under Impact MARINEBIO-12, resulting primarily from harassment due to additional vessels in the area and noise from air guns. The effects of air gun noise would not be of the same magnitude, because they would be low energy. However, the cumulative effect of the two surveys could still result in impacts on prey abundance, potentially causing harbor porpoise to expend more energy foraging over greater distances. Porpoises would also likely be dispersed away from core habitat, essentially attempting to avoid the surveys, which could also result in greater energy expenditure and potentially compromise overall fitness. This indirect effect on foraging and behavioral disturbance could result in effects on reproduction or long-term survival.

Marine traffic, including commercial and recreational vessels, would increase the potential for a cumulative effect due to noise disturbance from vessel propulsion. Relative to the number of vessels external to the Project, the seismic survey vessels would contribute less to the overall disturbance of marine mammals than other commercial and recreational vessels due to propulsion noise. However, the combined cumulative effect of propulsion noise with noise from air guns, echosounder, and the profiler would likely be most significant for harbor porpoises, resulting in behavioral avoidance, increased foraging effort, or indirect effects on reproduction.

While the potential for oil spills within the Project area would be low, as evidenced from the extremely low levels of oil spilled since 1995, the risk of a large oil spill would remain, given the amount of oil transported along California's coast. A large oil spill, while considered unlikely, could result in mortality or injury to marine mammals due to ingestion of oil (see Impact MARINEBIO-7). Depending on the type of oil spilled, certain products could remain in the area for long periods of time, increasing exposure of

marine mammals to oil. According to Würsig (1990, as cited in NSF 2011), whales that feed or reside close to shore in bays where oil may become trapped may be at greater risk of ingesting oil.

Heavy oiling could also cause a decrease in mobility, leaving the animal potentially unable to swim or forage (NSF and USGS 2011), thereby having an indirect effect on survival or reproduction. Thus, while relatively small amounts of oil spilled would be unlikely to result in a cumulative effect on harbor porpoises and other marine mammals, the potential effects of a large oil spill, while less likely, could be significant when combined with takes associated with the seismic survey.

Takes associated with NOAA research permits would not be likely to result in significant adverse effects on harbor porpoises due to the nature of the research activities permitted. For example, disturbance from aerial or vessel surveys would be short-term and not likely result in a population-level effect on reproduction or survival. Thus, cumulative effects of the Project, when combined with permitted marine mammal research, would not be anticipated.

Underwater noise and increased vessel traffic from the Morro Bay Dredging and Renovation Projects could disturb the resident harbor porpoise stock within the Bay. Increased amounts of sediment in the water column could also cause prey species to disperse to other areas and result in greater effort required for harbor porpoise foraging. Combined with the underwater noise disturbance and vessel traffic from the Project, significant cumulative effects on harbor porpoise could occur, as porpoises expended more energy attempting to avoid multiple projects or foraging farther up or down shore to avoid the disturbance.

The cumulative effect on marine mammals, especially the harbor porpoise, is expected to be significant, with most of the impact resulting from the Project.

4.4.6 Summary of Findings

As discussed above, the proposed Project could cause significant adverse impacts related to some marine biological resources. Accordingly, MMs have been developed to reduce those impacts, as summarized in Table 4.4-18~~20~~.

Table 4.4-18~~20~~ Summary of Significant Marine Biological Impacts and Mitigation Measures

Significant Impact	Applicable Mitigation Measures	Significance of Impact Post-Mitigation
Impact MARINEBIO-1: Vessel transit during mobilization and demobilization activities would potentially disturb or kill (due to collision) sea turtles, fish, or marine mammals	MM MARINEBIO-1 Marine Species Protocols.	LTS
Impact MARINEBIO-12: Injury or mortality to marine mammals would occur due to noise during seismic survey acquisition.	MM MARINEBIO-12a Expand Pre-Survey to 8.6 Miles (14 Kilometers) and Perform 10 Days in Advance of Survey.	SU
	MM MARINEBIO-12b Extend Aerial Surveys Throughout Survey Period.	
	MM MARINEBIO-12c Avoidance of Pinniped Haul-Outs.	
	MM MARINEBIO-12d Required Marine Mammal Observer Qualifications, Use of Equipment and Procedures to Enhance Detection Rates, and Performance of Nighttime Monitoring.	
	MM MARINEBIO-12e Increase Size of Exclusion Zone During Surveys.	
	MM MARINEBIO-12f Monitoring Using Two Scout Boats with Marine Mammal Observers During Surveys.	
	MM MARINEBIO-12g Perform Track Lines with Highest Mammal Densities During Daylight Hours.	
	MM MARINEBIO-12h Increase Pre-Ramp-Up Scan Period.	
	MM MARINEBIO-12i Adaptive Management in Case of Multiple Shutdowns.	
	MM MARINEBIO-12j Contingency for Sighting of North Pacific Right Whale.	
Impact MARINEBIO-13: Injury or mortality to Southern Sea Otters would occur due to noise during seismic survey acquisition	MM MARINEBIO-12a-i (see above)	SU

NOTES:
LTS = Less than Significant
SU = Significant Unavoidable Impact

APPENDIX H
MARINE MAMMAL TECHNICAL REPORT

PG&E offshore 3-D Seismic Survey Project EIR – Marine Mammal Technical Report.
Final Report March 14, 2012.
Jason Wood, Brandon Southall, and Dominic Tollit
Report code: SMRUL- NA0611ERM

This report is to be cited as:

Wood, J., Southall, B.L. and Tollit, D.J. (2012) PG&E offshore 3-D Seismic Survey Project EIR – Marine Mammal Technical Draft Report. SMRU Ltd.

Approved by Managing Director:

Douglas Mundie

For its part, the Buyer acknowledges that Reports supplied by the Seller as part of the Services may be misleading if not read in their entirety, and can misrepresent the position if presented in selectively edited form. Accordingly, the Buyer undertakes that it will make use of Reports only in unedited form, and will use reasonable endeavours to procure that its client under the Main Contract does likewise. As a minimum, a full copy of our Report must be appended to the broader Report to the client.

Project Name:	**PG&E offshore 3-D Seismic Survey Project EIR – Marine Mammal Technical Report**
Client:	ERM
Project reference number:	NA0611ERM
Lead Scientists:	Jason Wood[12], Brandon Southall[1], and Dominic Tollit[13]
Contact Information:	1. SMRU Ltd, UK HQ, Scottish Oceans Institute, University of St. Andrews, Fife, Scotland. 2. SMRU LLc, US Office, P.O. Box 764, Friday Harbor, Washington, USA. 3. SMRU Canada Ltd, Canada Office, 3069 6th Avenue West, Vancouver, BC, Canada.

Table of contents

Table of contents 1
List of Figures 3
List of Tables 4
1.0 Introduction 7
1.1 Report Goals 7
1.2 Population Impact Assessments 8
2.0 Summary review of anthropogenic noise effects on marine mammals 9
2.1 Noise overview 9
2.2 Classification of noise and species hearing to predict noise effects 9
2.3 Types of noise effects 10
2.4 Masking 11
2.5 Behavioral disturbance 14
2.6 Temporary and Permanent Hearing Loss and Basis for Acoustic Thresholds 15
2.7 Other physiological effects (stranding, bubble formation) 177
2.8 Echosounders and sub-bottom profilers 17
3.0 Methods 18
3.1 Temporal Scope 18
3.2 Geographical Scope and Animal Density Estimates 18
3.3 Impact Assessment Methodology 21
3.3.1. Severity ratings 22
3.3.2 Impact Ratings 27
3.4 Scope of potential Project stressors 288
3.5 Estimation of acoustic Impact (Ensonified area) 299
3.5.1 Preliminary scoping 299
3.5.2 Full acoustic take analysis 299
3.6 Scope of individual effects and selection of candidates for substantial adverse effects review299
3.7 Justification for use of additional threshold for acoustic take assessment (dual threshold criteria) 444
3.7.1 Current status of marine mammal noise exposure threshold: Auditory and behavioral thresholds of Southall et al. (2007) and implications of subsequent data 444
3.7.2 Proposed dual-threshold approach for take assessment 455
3.7.2.1 Current NMFS thresholds 455
3.7.2.2 Southall et al. (2007) derived exposure thresholds 455
3.7.2.2.1 Acoustic injury thresholds (PTS-onset) 455
3.7.2.2.2 Behavioral response thresholds 466
3.8 Marine mammal density estimate verification and validation 48
3.8.1 Inter-annual variability in mysticete 49
3.8.2 Depth dependent density assumptions 51
3.9 Acoustic take methodology 51
3.9.1 Depth and substrate dependent radii 53
3.9.2 Production tracklines and the inclusion of echosounder and sub-bottom profiler 53
3.9.3. Proportion of mysticetes foraging versus migrating 633
3.9.4 Density variability scenarios 633
3.9.5 Behavioral Avoidance Response (BAR) 633
3.9.6 Effectiveness of Marine Mammal Observers and PAM (Level A only) 644

3.9.7 Sea otter takes 655
4.0 Results 677
4.1. Level A acoustic takes 677
4.2 Level B acoustic takes 722
4.3 Acoustic take overview 777
4.3.1. Level A takes 777
4.3.2 Level B takes 78
4.3.3 Sea otter take analyses 79
4.4 Impact Analysis 822
4.4.1 Significance criteria a (NMFS NOAA rms Level B individual takes) 822
4.4.2. Significance criteria b-e (substantial adverse effects) 822
4.4.2.1 Impact rating matrices for key stressors 822
4.4.2.2 Acoustic impacts of combined active sources (airguns, echosounder and sub-bottom profiler) – Level A 833
4.4.2.3 Acoustic impacts of combined active sources (airguns, echosounder and sub-bottom profiler) – Level B 855
4.4.2.4 Acoustic impacts of airguns – Secondary prey effects (indirect) 877
4.4.2.5 Acoustic effect of vessel noise – Level B harassment (Indirect) 877
4.4.2.6 Acoustic effect of survey aircraft – Level B harassment (Indirect) 888
4.4.2.7 Entanglement in airgun or hydrophone strings – Injury/Mortality (direct) 89
4.4.2.8 Entanglement in geophone strings – Injury/Mortality (direct) 90
4.4.2.9 Oil contamination – Injury/Mortality (direct) and Life function effects (indirect) 90
4.4.2.10 Vessel interaction – Injury/Mortality (direct) and non-acoustic disturbance (indirect). 92
4.5 Impact rating and substantial adverse effects overview. 94
4.5.1.1 Gray whale 966
4.5.1.2 Fin whale 966
4.5.1.3 Humpback whale 977
4.5.1.4 Blue whale 988
4.5.1.5 Minke whale 988
4.5.1.6 Short-beaked common dolphin 99
4.5.1.7 Long-beaked common dolphin 99
4.5.1.8 Small beaked whale species 100
4.5.1.9 Harbor propoise (Morro Bay stock) 100
4.5.1.10 Dall's porpoise 101
4.5.1.11 Pacific white-sided dolphin 102
4.5.1.12 Risso's dolphin 102
4.5.1.13 Northern right whale dolphin 103
4.5.1.14 Bottlenose dolphin – California coastal stock 1033
4.5.1.15 Sperm whale 104
4.5.1.16 Pacific Harbor seal 104
4.5.1.17 California sea lion 105
4.5.1.18 Southern sea otter 105
4.6 Potential adverse effects summary for Alternatives. 106
5.0 Mitigation 106
5.1 Decreasing effects on ESA-listed fin, humpback and blue whales during high densities occurrences 107

5.2 Decreasing effects on resident species, especially harbor porpoise 1077
5.3 Decreasing numbers of Level A acoustic takes for all species 1088
5.4 Decreasing potential of Level A takes for all species 1099
6.0 References 110

List of Figures

Figure 3.1 - Outline of impact assessment methodology..... 22
Figure 3.2 - Application of the individual sites modeling results to the seismic tracklines relevant to the proposed Project and Alternative 1.....54
Figure 3.3 - Application of the individual sites modeling results to the seismic tracklines relevant to Alternative 2.....55
Figure 3.4 - Cumulative SEL modeling results for Box 1 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB $MW_{LF,}$ 198 dB $MW_{MF,}$ 179 dB MW_{HF}, and 186 dB MW_{PP}.....56
Figure 3.5 - Cumulative SEL modeling results for Box 2 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB $MW_{LF,}$ 198 dB $MW_{MF,}$ 179 dB MW_{HF}, and 186 dB MW_{PP}.....57
Figure 3.6 - Cumulative SEL modeling results for Box 3 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB $MW_{LF,}$ 198 dB $MW_{MF,}$ 179 dB MW_{HF}, and 186 dB MW_{PP}.....58
Figure 3.7 - Cumulative SEL modeling results for Box 4 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB $MW_{LF,}$ 198 dB $MW_{MF,}$ 179 dB MW_{HF}, and 186 dB MW_{PP}.....59
Figure 3.8 - Cumulative SEL modeling results for Zone 1 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB $MW_{LF,}$ 198 dB $MW_{MF,}$ 179 dB MW_{HF}, and 186 dB MW_{PP}.....60
Figure 3.9 - Cumulative SEL modeling results for Zone 2 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB $MW_{LF,}$ 198 dB $MW_{MF,}$ 179 dB MW_{HF}, and 186 dB MW_{PP}.....61
Figure 3.10 - Area ensonified by all active acoustic sources combined during proposed Project survey after application of NMFS Level B threshold.....62
Figure 4.1 - Distribution of overlap of sea otter distribution and NMFS Level A criteria for the Proposed Project.....81

List of Tables

Table 3.1 - Density estimates of marine mammal species and species groups. Lower and Upper estimates represent 90% lognormal confidence intervals in the SERDP-SDSS Density Model. Also provided are Standard deviation (SD) and Coefficient of Variation (CV) and source of the density estimate. Potential substantial effects analyses were undertaken for those species highlighted in bold (see Sections 3.5 and 3.6 for justification).....20
Table 3.2 - Summary of dual threshold criteria for estimating acoustic takes and steps for determining magnitude of effect.....23
Table 3.3 - Descriptions of the levels within four intensity components used to rate severity.....26
Table 3.4 - Severity rating matrix methodology.....27
Table 3.5 - Impact rating matrix methodology 27
Table 3.6 - Potential Project stressors identified in scoping process.....28
Table 3.7 - Summary of biological context and preliminary acoustic effects scoping review. A detailed biological resources review is presented in Section 4.4.4 of the EIR document.....31
Table 3.8 – Modified Injury Sound Exposure Level (SEL) thresholds for multiple pulses used in this analysis and those originally proposed by Southall et al. (2007) to estimate onset of acoustic injury (Level A –PTS.....47
Table 3.9 - Probabilistic Disturbance rms sound pressure level thresholds (M-weighted) used in the current analysis to predict a Level B behavioral response. For comparison, the NMFS threshold for behavioral response for all marine mammals is 160 dB re: 1 µPa (rms, un-weighted). Probabilities are not additive and reflect single points on a theoretical respons curve.....48
Table 3.10 Summary of notable humpback and blue whale sightings during local vessel sighting surveys by Calambokidis et al. (2002a; 2003; 2004) and NOAA porpoise surveys (1998-2007).....50
Table 3.11 - Biological context and correction factors used in take analysis of candidate species. See text for details. Southall functional hearing groups as follows; LFC: low frequency cetaceans, MFC: mid frequency cetaceans, HFC: high frequency cetaceans, Pw: pinnipeds in water.....66
Table 4.1 - **Proposed Project** (Boxes 1,2,3,4) Level A takes of special status species calculated using Injury SEL and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (>100%), orange highlight medium magnitude (50-100%) and yellow low magnitude (10-50%), based on percentage of Residual Potential Biological Removal (PBR). Endangered species are denoted in italics. Take estimates have been modified to take account of group-specific behavioural avoidance responses (range 90-99%) whereby animals avoid the area ensonified to the Level A threshold, as well as detection success of animals entering or within the exclusion zone using MMOs and PAM. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint. Gray whales not included in table as densities expected to be zero during proposed survey period.....68
Table 4.2 - **Alternative 1** (Boxes 1,2, 4) Level A takes of special status species calculated using Injury SEL and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (>100%), orange highlight medium magnitude (50-100%) and yellow low magnitude (10-50%), based on percentage of Residual Potential Biological Removal (PBR). Endangered species are denoted in italics. Take estimates have been modified to take account of group-specific behavioural avoidance responses (range 90-99%) whereby animals avoid the area ensonified to the Level A threshold, as well as detection success of animals entering or within the exclusion zone using MMOs and PAM. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS

Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint……69
Table 4.3 - **Alternative 2 (Zones 1 and 2)** Level A takes of special status species calculated using Injury SEL and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (>100%), orange highlight medium magnitude (50-100%) and yellow low magnitude (10-50%), based on percentage of Residual Potential Biological Removal (PBR). Endangered species are denoted in italics. Take estimates have been modified to take account of group-specific behavioural avoidance responses (range 90-99%) whereby animals avoid the area ensonified to the Level A threshold, as well as detection success of animals entering or within the exclusion zone using MMOs and PAM. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint. Notes: [1] Excluding Echosounder and Sub-bottom profiler……70
Table 4.4 - Percent of each Alternative (A) Level A take compared with the proposed Project (P) Level A take, for Injury SEL, NMFS Minimum and NMFS Maximum methods. Cells color shaded in grey indicate a reduction in take compared to the proposed Project. Notes: [1] Excluding Echosounder and Sub-bottom profiler……71
Table 4.5 - **Proposed Project** Level B takes of special status species calculated using Probabilistic Disturbance rms and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (Listed species >2.5%, non-listed species >25%), orange highlight medium magnitude (Listed species 1.25-2.5%, non-listed species >15-25%) and yellow low magnitude (Listed species >1 individual, non-listed species 5-15%), based on percentage of minimum population estimate. Endangered species are denoted in italics. Take estimates have been modified to include group-specific behavioural avoidance responses whereby animals avoid the Level A threshold area. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint. Gray whales not included in table as densities expected to be zero during proposed survey period……73
Table 4.6 - **Alternative 1** Level B takes of special status species calculated using Probabilistic Disturbance rms and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (Listed species >2.5%, non-listed species >25%), orange highlight medium magnitude (Listed species 1.25-2.5%, non-listed species >15-25%) and yellow low magnitude (Listed species >1 individual, non-listed species 5-15%), based on percentage of minimum population estimate. Endangered species are denoted in italics. Take estimates have been modified to include group-specific behavioural avoidance responses whereby animals avoid the Level A threshold area. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint……74
Table 4.7 -**Alternative 2** Level B takes of special status species calculated using Probabilistic Disturbance rms and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (Listed species >2.5%, non-listed species >25%), orange highlight medium magnitude (Listed species 1.25-2.5%, non-listed species >15-25%) and yellow low magnitude (Listed species >1 individual, non-listed species 5-15%), based on percentage of minimum population estimate. Endangered species are denoted in italics. Take estimates have been modified to include group-specific behavioural avoidance responses whereby animals avoid the Level A threshold area. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum

quantifies the 'intensity' of the survey within the Project footprint……..75
Table 4.8 - Percent of each Alternative (A) Level B take compared with the proposed Project (P) Level B take, for Probabilistic Disturbance rms, NMFS Minimum and NMFS Maximum methods. Cells color shaded in grey indicate a reduction in take compared to the proposed Project. Notes: [1] Excluding Echosounder and Sub-bottom profiler……..76
Table 4.9 - Estimates of otter take from Level A acoustic disturbance from acoustic survey (NMFS 180 dB rms) and from vessel proximity (30% at 100 m per Udevitz 1995)……..80
Table 4.10 - Severity Rating (SR) and final Impact Rating (IR) for Level A (Injury SEL and NMFS Minimum) takes for the proposed Project and Alternatives 1-2. High Impact Ratings are depicted in red and denote potential substantial effects. M denotes medium severity rating based on moderate magnitude level, while M* denotes medium severity rating based on a low magnitude. Empty cells represent negligible ratings……..84
Table 4.11 - Severity Rating (SR) and final Impact Rating (IR) for Level B (Probabilistic Disturbance rms and NMFS Minimum) takes for the proposed Project and Alternatives 1-2. High Impact Ratings are depicted in red and denote potential substantial effects. H denotes High severity rating based on high magnitude level, while H* denotes high severity rating based on a moderate magnitude. Empty cells represent negligible ratings……..86

1.0 Introduction

1.1 Report Goals

The proposed CCCSIP Project would take place in central California. The main component of the Project is to undertake a 3D seismic survey in the relatively shallow waters depths (<400 m) in the vicinity of the Diablo Canyon Power Plant. The proposed Project description has an 81¼ day schedule and includes up to 40¼ days of nearshore 3D seismic surveys across four target areas. There are also related onshore activities. Two alternatives are proposed. Alternative 1 excludes one of the northern target areas. Alternative 2 has a 93 day schedule and includes up to 53 days of seismic surveys across 2 zones (Zone 1, the northern area and Zone 2, the southern area). The proposed Project was modified in January 2012. Prior to this date, Alternative 2 was considered the Project. A sound source verification period of 5 days is scheduled to validate expected source output characteristics and propagation predictions based on empirical measurements.

At least 22 species of the order *Cetacea* (whales, dolphins, and porpoises), 6 species of the suborder P*innipedia* (seals, sea lions and fur seals) and 1 species of the family *Mustelidae* (sea otters) are known to occur in the waters (<2000m depth) of central California. This supplementary technical report aims firstly to review the CCCSIP Project to assess the potential level of impacts to marine mammals from the Project, especially from in-water airgun-related seismic activities. Secondly, it makes recommendations for additional mitigation measures aimed at reducing any residual impacts. Lastly, it assesses the proposed alternatives for comparison.

Significance thresholds for the project were pre-defined as the following:

a) ***Result in the "take" of special status species in accordance with current NOAA Fisheries policies for marine mammals, and/or result in underwater or in-air noise levels that are equal to or exceed current NOAA Fisheries guidelines for Level A or B harassment of marine mammals (i.e. in-water levels exceeding 160 dB re: 1 µPa root mean square (rms), or in-air levels generally at or above 90 dBA re: 20 µPa for level B harassment; higher levels are used for level A harassment).***

b) ***A substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game, the U.S. Fish and Wildlife Service, or the NOAA Fisheries.***

c) ***A substantial interference with the movement of any native resident or migratory fish or wildlife species, or with established native resident or migratory wildlife corridors, or impede the use of a native wildlife nursery site.***

d) ***A substantial reduction in the habitat of a fish or wildlife species.***

e) ***Cause the population of a fish or wildlife population to drop below self-sustaining levels.***

Thus, the main goals were firstly, to define the key Project stressors, as well as the appropriate geographical scope of potential impacts, relevant time period and methods for the assessment. Secondly, to determine those species that are likely to have a "take" at NOAA Level B harassment levels or above (Significance Threshold a). Thirdly, determine a 'shortlist' of candidate species and assess residual (after incorporating the applicant proposed measures, APMs) potentially substantial adverse effects at the population (stock) level (i.e., Significance Threshold b-e), including Level A or B harassments. For the population level assessment, a **dual threshold criteria** approach was adopted to estimate acoustic takes and assess potential impact. Newly developed threshold criteria (aiming to incorporate recent scientific findings and methodologies, notably those recommended by Southall et al.

2007), were used in the population level assessment and results compared with takes using the current NOAA Fisheries (NMFS) thresholds for defining Level A and B acoustic harassment.

1.2 Population Impact Assessments

There are major limitations in the existing information available to support the development and application of any procedure for accurately assessing potential seismic impacts on marine mammal populations, particularly on the west coast of the U.S. where these events and scientific measurements of their potential impact are quite rare. Consequently, the level of scientific uncertainty underpinning many elements of our assessment framework varies considerably. Notably, data is clearly limited in determining appropriate species-specific noise thresholds to determine the radius of both hearing and behavioral impacts (e.g., Southall et al. 2007; Gedamke et al. 2011), as well as quantitatively linking subsequent cumulative individual-level effects to population demographic parameters (see NRC 2005). Population viability, energetic and behavioral/movement models, while considered informative, were not within the scope of this assessment review. Our information review instead aims to make a balanced, pragmatic but precautionary (where data is sparse or highly variable) evaluation based on information in the literature, our dual criteria take analysis and expert opinion. Following preliminary scoping, we focused our impact assessment on 16 key species considered at potential risk of substantial adverse effects. Robust estimates of animal density that incorporate temporal and spatial variability are considered a vital input to any impact assessment. However, for wide-ranging species, accurate local estimates for a particular season are hard to obtain and certainly (for many species) are not easily predictable, as they can often reflect environmental fluctuations and the vagaries of lower-level trophic recruitment success (Peterson et al. 2006). In such cases, scenario assessments that explore potential variability in density are useful and relevant verification information from field scientists and local operators should be utilized to ensure reality and reliability. In addition, appropriate pre-survey assessment measures become increasingly important for potentially susceptible species that show strong inter-annual density variability, as does the evaluation of the biological importance of the zone of impact and levels of life-history adaptability that vary across resident, migrating or dispersed wide-ranging species.

For this project, we developed a simple matrix-based methodology to evaluate the significance of potential impacts based on their context, intensity and likelihood of occurrence (taking into account the APMs). Criteria for ESA-listed species require lowered thresholds for precautionary reasons.
Given the levels of known variance in key parameters affecting potential responses as well as the acknowledged uncertainty in assessing acoustic impacts, it was also considered necessary to explore the potential effects of differing circumstances and methodological approaches. The resulting ranges in the number of harassments (or takes) predicted in various theoretically “possible” scenarios, potentially may lead to a range of different impact predictions from best to worse case scenarios. Precautionary scenarios combined with the impact matrix methodology are considered useful to focus the assessment on which taxa or species in particular require additional mitigation and highlight potential population scale of effects considerations that include non-standard approaches.

The potential effects of anthropogenic noise on marine mammals is a rapidly expanding field of science and a review of current knowledge is warranted, especially when developing and interpreting acoustic take analyses.

2.0 Summary review of anthropogenic noise effects on marine mammals

2.1 Noise overview

Both solitary and social mammals rely on communication and sensing of their environment for various important life functions (reproduction, foraging, etc.). This communication and environmental sensing utilizes a number of production and sensory organs. However, a species' ability to utilize different modalities depends on physical limitations imposed by the environment in which that species communicates. Water is relatively opaque to light and chemicals diffuse slowly. This has placed a selective pressure on marine mammals that has resulted in a heavy reliance on sound to sense and communicate within their environment. Because of this, an increase of acoustic noise in the marine environment can have potentially serious implications for the basic life functions of marine mammals.

The oceans are noisy environments. Sources of noise include wind, waves, rain and earthquakes (abiotic noise sources) as well as shrimp, fish and marine mammals (biotic noise sources). However, over the last two decades, concern has been mounting over the noises that human activity generates (anthropogenic noise). This noise is either generated as a byproduct of an activity (shipping, construction, etc.) or used as a method of gathering data (sonar, depth sounding, seismic surveys).

The impact this anthropogenic noise has on marine mammals varies a great deal depending on a variety of biological and environmental factors, from no effect to potentially lethal. A large amount of research over the last two decades has attempted to quantify these effects. There are a number of reviews on this subject (Richardson et al. 1995; Southall et al. 2007; Nowacek et al. 2007; Gotz et al. 2009), which we briefly review, then focus specifically on reported effects from seismic surveys, especially the more recent and relevant scientific studies.

2.2 Classification of noise and species hearing to predict noise effects

Mammalian hearing evolved on land and follows a fairly standard architecture with an outer ear that collects sound from the environment and conveys it to the middle ear where it is amplified and conveyed into the inner ear which acts as a bandpass filter. This filtering happens in the cochlea where hair cells in different regions are sensitive to different frequencies of sound. This basic architecture holds true for most terrestrial mammals and, with a few modifications for an aquatic existence, for marine mammals as well. Most marine mammals have lost external evidence of the outer ear and have developed alternative pathways to convey the sound to the middle ear. However, the middle and inner ear are little changed, other than specializations that allow for different hearing ranges (Wartzok and Ketten 1999).

Southall et al. (2007) classify marine mammals into five functional hearing groups. While these fall along taxonomic lines to some extent, they were more explicitly defined based on similarities in known or expected hearing capabilities, as well as underwater and aerial hearing for relevant groups. These groups include three cetacean groups (low-frequency, mid-frequency, high-frequency) and two pinniped groups (in water, in air). Low frequency cetaceans include all the baleen whales (suborder Mysticeti), while toothed whales (suborder Odontoceti) are split between mid and high-frequency groups. The mid-frequency group comprises most dolphin species, false killer whales, sperm whales, beaked whales, etc., while the high-frequency group is made up of porpoises and a few other high frequency specialists. Pinniped in-air versus in-water reflects this amphibious group's different hearing capabilities in water and air. This group includes all species of seals, sea lions, fur seals and the walrus. Based on the hearing similarities within these functional hearing groups, Southall et al. (2007) developed a series of frequency

weighting curves (termed M-weighting) that allow one to compensate for the hearing abilities of these groups while calculating the received levels of various sounds.

Because of the lack of direct data on hearing and the effect of noise on hearing in most marine mammal species, it more appropriate to make inferences on hearing damage and hearing loss in marine mammals based on research on terrestrial mammals when data are not available for marine mammals (Southall et al. 2007). When permanent hearing loss occurs in terrestrial or marine mammals, it is usually caused by damage to the hair cells in the cochlea. For all mammals therefore the following general 'rules' apply to patterns of hearing loss. Sudden, loud and impulsive sounds can cause hearing damage, as can long exposures to quieter sounds. Temporary or permanent loss of hearing will occur almost exclusively for noise within the animals hearing range, with the maximum hearing loss commonly occurring ~ ½ an octave above the frequency of the main energy of the damaging noise.

Because of this amplitude/duration aspect of noise and the frequency dependency of the receiver in terms of the potential for hearing damage (and other noise effects), it makes sense to classify noise by its amplitude/duration, and the receivers (animal taxa) into groups that hear similar frequency ranges. Southall et al. (2007) classify anthropogenic sounds into the following groups: non-pulses, single pulses, and multiple pulses. Non-pulses are single or repeated acoustic events that have less than 3 dB of difference between amplitude measures using a long versus short time window. Examples include ship noise, construction, low frequency sonar, etc. Single pulses are single acoustic events (one per 24 hour period) that have a greater than 3 dB difference in amplitude measurements using long versus short time windows. Examples include a single explosion, a sonic boom, etc. Multiple pulses are more than one pulse in a day and include activities like pile driving, some depth sounders and multiple firings of seismic airguns.

2.3 Types of noise effects

Sound is limited in duration by the time over which the source produces it. To be detected by an animal at sufficient levels to induce an impact, the receiver must be within sufficient proximity to the source. In other words, the animal must be within sufficient range at the time the sound is being produced, for the sound to have an impact on it. In addition, the amplitude, duration and frequency of the noise, as well as the hearing ability and behavioral state of the animal, all influence how or if there is an impact on the animal. Impacts (if any) range from acoustic masking to disturbance, temporary hearing loss, permanent hearing loss, and other physiological effects, including stranding and/or death. Evidence has been mounting that acoustic impacts are occurring at all these levels in marine mammals. For example, killer whales increase the amplitude of their calls to avoid masking by boat noise (Holt et al. 2009), commercial shipping may dramatically increase calls of con-specific baleen whales (Clark et al. 2009), migrating gray whales change direction to avoid noise from seismic surveys (Malme et al. 1984) and temporary hearing loss has been demonstrated in a captive bottlenose dolphin (e.g., Mooney et al. 2009a). Of higher concern, there have been a number of strandings of beaked whales in areas where naval sonar exercises have recently occurred. There is uncertainty about the mechanism of injury (whether the injuries were caused by high levels of sonar or by a behavioral reaction of the animals to the sonar at levels below those which would cause direct tissue damage), but strong evidence exists that beaked whale species are at risk from naval sonar in some circumstances (Cox et al. 2006; D'Amico et al. 2009).

In spite of this mounting evidence, there are still large data gaps and uncertainty. For example masking can be tested directly in captive species (e.g., Erbe 2008), but in wild populations it must be either modeled or inferred from evidence of masking compensation (see masking section below). Likewise in studies of hearing loss, tests can be done in captivity and models applied to estimate this impact in the wild. All of these impact models rely on three main inputs; the propagation of the noise, the hearing abilities of that species, and the behavioral reaction of that species to the noise. All of these inputs are complex and require a number of other additional inputs themselves. Modeling noise propagation has benefited from concerted efforts over many years, but can vary a great deal with local bathymetry and local oceanographic conditions, such that noise is not always lower in amplitude the further it has travelled (e.g., Madsen et al. 2006a). A number of propagation models are however available (Range Dependent Acoustic Models (RAM), ray tracing, normal modes, parabolic equations, wave number integration) that do well at approximating *in situ* noise propagation. These predictions can and should be verified with tests on site (as has been proposed for this study) and can vary a great deal by distance, depth and frequency.

Hearing in marine mammals is multifaceted and much more complicated than just understanding the hearing sensitivity across frequency (auditory curve). For example, robust masking predictions require knowledge of the frequency integration of the ear (critical bandwidth), as well as temporal integration, critical ratio, directivity index, etc. Hearing loss is affected by the amplitude, frequency, duration, duty cycle, and directionality of the noise to which the animal is exposed, as well as intrinsic features of the exposed animal including its susceptibility to and recovery from noise exposure. Many of these variables can only be tested accurately in captive animals, but it is costly, time consuming and limited to certain marine mammal groups given logistical considerations (e.g., the lack of a sufficient facility to house and test the hearing of a large whale). Due to this fact, while the hearing abilities of over 20 species have been tested so far, only a few species (3-4) and a few individuals have been tested comprehensively. Therefore most of these variables have not been tested directly in most species of marine mammals, and little to nothing is known about the individual variation of these variables within a species. Likewise behavioral reactions are easier to quantify in captivity, but suffer from small sample size and difficulty in extrapolating these measurements to wild populations. Meanwhile behavioral reactions in wild populations are difficult to quantify (especially if the reaction is subtle), are logistically challenging, and can vary a great deal depending on a number of factors (see behavioral reaction section below). This leads to a situation where our ability to predict acoustic impacts is impaired by our lack of appropriate input parameters and lack of understanding of the variability in those parameters.

2.4 Masking

Acoustic masking occurs when a noise impedes the ability of the animal to perceive a signal. For this to occur the noise must be loud enough, have similar frequency content to the signal, and must happen at the same time. We consider each of these signal and noise characteristics (loudness, frequency content and timing) in sequence. The minimum amplitude at which a signal can be heard above the background noise is termed the Critical Ratio (CR). More specifically, the CR is the amplitude difference between the pure tone signal (in dB re 1µPa) and the spectrum level of the background noise at that frequency (in dB re 1 $\mu Pa^2/Hz$) that is needed for the animal to hear the signal. A signal that is received at a level below the CR in relation to the background noise will be masked. Critical ratios at low frequencies are fairly constant, but at mid frequencies start to increase with frequency. Johnson et al. (1989) found a roughly constant CR for a Beluga whale from 40 to 2,000 Hz (~18 dB), but that the CR increased up to ~40 dB at 100 kHz. Au and Moore (1990) measured CRs in a bottlenose of ~31 dB at 30 kHz and ~45 dB at 140 kHz.

Likewise Southall et al. (2003) found increasing CRs with frequency in pinnipeds and also that they were very similar for individual seals and sea lions tested both in air and water; that is, for pinnipeds the masking effect of noise is similar regardless of the medium in which they are exposed.

In addition to the amplitude difference between the signal and the noise, the frequency content of the signal and noise also affect the level of masking. As discussed above, the inner ear acts as a bandpass filter in converting the received sound from mechanical to electrical energy. This bandpass filtering is achieved by having different hair cells along the cochlea 'tuned' to different frequencies.
However these hair cells are not just sensitive to the frequency they are 'tuned' to, but also to a range of frequencies (a band) around this frequency of highest sensitivity. Thus the same hair cell that responds to a pure tone signal, will at the same time be responding to a band of frequencies from any noise that is present. The energy from this band of noise will be added to the stimulation of that hair cell and if enough noise it present will have more combined energy than the signal tone and therefore cause masking. The width of the frequency band over which hair cells are sensitive is called the Critical Bandwidth (CBW). Noise outside the CBW will have little effect on the detection of a signal in that band, unless the noise is very loud. CBWs tend to be proportional to the frequency of sensitivity, rather than a constant bandwidth (i.e. CBW are described as 1/3 of an octave rather than 1 kHz).The wider the CBW the more likely broadband noise is to mask a signal. At the upper and lower end of hearing though, CBWs tend to be wider, and therefore these regions may be more susceptible to masking (Richardson et al. 1995).

The relative timing of a signal and noise also impacts the level of masking. The noise must occur at the same time as the noise to produce masking. In addition, repeating a signal, or lengthening it may also reduce the amount of masking. For example, there is some evidence that repetition of signals in seals and odontocetes increases their detectability (Moors and Terhune 2004; Johnson 1991). Likewise, on small time scales, increases in duration of a signal can increase their detectability (Kastelein et al. 2010).

Studies demonstrating the masking effects of anthropogenic noise on marine mammals typically find masking impacts by documenting masking compensation strategies (responses the animals use to overcome the masking effects of the noise). For example, in response to anthropogenic noise marine mammals have increased the duration of their calls (humpback whales: Miller et al. 2000), altered the pitch of their calls (right whales: Parks et al. 2007), called more or less often (blue whales: Di lorio and Clark 2009) and called louder (killer whales: Holt et al. 2009). There have also been efforts to quantitatively predict the spatial zones associated with potential masking effects from anthropogenic sounds (e.g., Clark et al. 2009). Although masking effects have been documented in a number of species, it is very difficult to quantify the survival or reproductive consequences of this masking on an individual, let alone quantifying the effect of masking on the population. The National Research Council (NRC, 2005) developed a conceptual model (termed Population Consequences of Acoustic Disturbance: PCAD) to help guide the process of quantifying these population level effects from acoustic disturbances of individuals. Research in this area is ongoing and it is expected that potential impacts on communication ability for marine mammals in areas of elevated noise may increasingly become part of the process in future environmental assessments.

The sound generated by seismic surveys are, by design, brief, impulsive and low frequency (strongest from 10 to 120 Hz), but energy has been measured up to 100 kHz (Richardson et al. 1995; Bain & Williams 2006; Gotz et al. 2009), resulting in overlap with the hearing sensitivities of not only baleen

whales, but also odontocetes and pinnipeds. For example, Goold and Fish (1998) found that noise from seismic airguns dominated the 200Hz-22 kHz bandwidth at ranges of up to 2km from the source and that even at 8km airgun noise exceeded background noise at frequencies of up to 8 kHz. Airgun direct path pulses are quite short on the order of tens of milliseconds, but the effective source level of full-scale airgun arrays can be quite high (up to ~260 dB (p-p) re 1 µPa @ 1m; Gotz et al. 2009) and the duration of the signal is affected by multipath propagation (e.g., reverberation can occur). The CCCSIP Project description states that airgun pulses would occur every 15 to 20 seconds (giving a pulse every 30 to 50m) during the survey, however the narrative also discusses producing pulses every 25m which translates into an airgun pulse every ~11 seconds, and more recently every 37m. Masking impact of this temporal scale of noise source needs to consider how vocal species use different sounds (phrases, songs, bouts) and the timescales they occur over. The frequency overlap between the primary energy of airgun pulses and baleen whales is considerable, which increases the likelihood of masking. The overlap in time between transmitted airgun impulses and communication however is relatively small with most species producing sounds from 1 to 30 seconds long, and humpbacks making songs up to 30 minutes long (Richardson et al. 1995; Stafford et al. 2011). Given the disparity in temporal features, baleen whales are considered likely to be able to detect conspecific calls in between airgun pulses, but some of the salient acoustic features that code information could potentially be obscured. However, although the amplitude of the seismic pulses will usually be lower at greater distances from the source, multipath arrivals can increase the relative duration of a transmitted pulse because the energy gets there through multiple paths, thus adding to the potential for masking. Related to these multiple arrivals, in a reverberant environment, the duration of the seismic pulses will also increase with transmission distance, such that at large distances the pulse may become more of a continuous noise. For example, Clark and Gagnon (2006) documented a cessation of fin whale vocalizations across an area of 10,000 square nautical miles during a seismic survey. Vocalizations resumed after the end of the survey suggesting the whales were not displaced, but merely stopped vocalizing. This may be an indication that masking was occurring and that cessation of vocalizing during the occurrence of the airgun noise was the best option from a cost-benefit perspective for the exposed whales. It is therefore plausible that either, baleen whales exposed to this proposed survey may stop vocalizing, or that their calls may be masked. Further evidence of potential baleen whales masking is suggested by Di Iorio and Clark's (2009) finding that Blue whales increased their calling rate during a seismic survey using sparkers (a lower amplitude seismic survey technique). However migrating whales would be exposed to the seismic pulses for less than a day and therefore not cause long term masking for these individuals.

There is evidence that mid frequency cetaceans continue to utilize calls and echolocation during seismic surveys. Goold and Fish (1998) reported whistles and clicks from common dolphins during a seismic survey although they did not specifically test for masking effects. Miller et al. (2009) also reported a continuation of foraging clicks from sperm whales exposed to airgun noise. There was some evidence (although not significant perhaps due to small sample size) that buzz train rates decreased during seismic exposure and one whale rested on the surface for longer than usual, but began a foraging dive after the end of the seismic exposure period of the experiment. However, because of the lower frequency overlap, masking is less likely in mid frequency cetaceans than it is in baleen whales. Likewise, with high frequency cetaceans, the frequency overlap will be even lower. No data is available to our knowledge of vocalizing high frequency cetaceans exposed to seismic airguns; however data are available for pile driving (another multiple impulse noise). Carstensen et al. (2006) report detecting echolocation clicks of harbor porpoises before and during construction of an offshore wind farm, although the latency between echolocation bouts was much larger during construction than before. This

could mean that harbor porpoise were displaced during construction or that they ceased echolocating during the construction. Given known harbor porpoise skittishness to human activities (Johnston 2002; Olesiuk et al. 2002; Kastelein et al. 2006, Madsen et al. 2006b), the former is more likely, which would also likely lead to less masking potential from multiple impulsive sounds such as airguns.

Pinniped vocalizations are generally low frequency (<10 kHz) and are usually associated with mating displays, territoriality or mother-pup interactions (Richardson et al. 1995). Harbor seals produce low frequency (<4kHz) displays under water for courtship and pups make calls with fundamental frequencies of ~350Hz. Elephant seals, California sea lions, and Steller sea lions all produce low frequency sounds, but usually above water in relation to social interactions, aggression, territoriality and mother-pup interactions (see Richardson et al. 1995). Some of these sounds either travel through the water when made by an individual with its head above the surface, or are made underwater. However given the nature of the context in which these sounds are made (close distance social situations), they are likely but one of several modalities in which those interactions are mediated. Sea otter vocalizations seem to be restricted to airborne signals (Richardson et al. 1995) so reducing likelihood of masking from underwater airgun noise.

2.5 Behavioral disturbance

Disturbance from noise can take many different forms from very subtle shifts in breathing patterns or slight changes in direction of swim to startle responses that lead to flight of the animal from the area. As more studies have documented noise disturbance in various species, it has become apparent that the response of an individual to noise will vary greatly depending on a number of different factors. Wartzok et al. (2003) categorized these variables into two groups as follows; **internal**, animal-specific factors that affect an individual's response to noise and **externa**l factors related to the context of exposure that mediate the probability of different types of behavioral response. Internal factors include:

- individual hearing capability, activity pattern, and motivational and behavioral states at the time of exposure;
- past exposure of the animal to the noise, which may have led to habituation or sensitization;
- individual noise tolerance; and
- demographic factors such as age, sex, and presence of dependent offspring.

While external factors include:

- non-acoustic characteristics of the sound source, such as whether it is stationary or moving;
- environmental factors that influence sound transmission;
- habitat characteristics, such as being in a confined location; and
- location, such as proximity of the animal to a shoreline.

These internal and external factors make it logical to develop separate thresholds for behavioral disturbance for cetaceans and pinnipeds (e.g., see Ellison et al. 2011). Behavioral responses of cetaceans and pinnipeds to noise have been extensively reviewed (NSF-USGS 2011; Nowacek et al. 2007; Southall et al. 2007) and all report that responses, even within a species, vary greatly as a function of a number of biological and environmental parameters.

Mysticetes: A number of baleen whale species exhibit clear behavioral reactions to seismic surveys. Bowhead whales (*Balaena mysticetus*) have received the most research attention in regards to noise from seismic surveys. At received levels from 120-130 dB re: 1 µPa (rms) migrating bowhead whales

show strong avoidance reactions (Richardson et al. 1999; Manly et al. 2007). However bowheads appear much more tolerant of seismic noise while they are feeding and remain in the area until levels exceed ~160 dB re: 1µPa (rms) (Richardson et al. 1986; Ljungblad et al. 1988; Miller et al. 2005). Likewise feeding humpback whales show behavioral responses starting at levels from 150-159 dB re: 1µPa (rms) (McCauley et al. 1998). Migrating gray whales changed their course starting at received levels of 110 dB re: 1µPa (rms) and by the time the levels reached 130 dB re: 1µPa (rms), 80% of the migrating whales were changing their course (Malme et al. 1984).

Odontocetes: Dolphin and other toothed whale species seem to show a variety of reactions to seismic surveys. Stone and Tasker (2006) reported on observations undertaken during 201 seismic surveys in UK and adjacent waters and results demonstrate that cetaceans can be disturbed by seismic exploration. Small odontocetes showed the strongest lateral spatial avoidance (extending at least as far as the limit of visual observation) in response to active airguns, while killer whales (and mysticetes) showed more localized spatial avoidance. Long-finned pilot whales showed only a change in orientation and sperm whales showed no statistically significant effects. The authors suggested that the different taxonomic groups of cetaceans may adopt different strategies for responding to acoustic disturbance from seismic surveys; some small odontocetes move out of the immediate area, while the slower moving mysticetes orient away from the vessel and increase their distance from the source, but do not move away from the area completely. In contrast, sperm whales show little response to seismic surveys, but may disrupt/delay foraging (Mate et al. 1994; Madsen et al. 2002; Stone 2003; Stone and Tasker 2006; Jochens et al. 2008; Miller et al. 2009). Other studies document that small odontocetes show some avoidance at distances less than 1 km (Stone 2003; Gordon et al. 2004; Stone and Tasker 2006), however some also approach the seismic vessel and even bow ride (Haley and Koski 2004; Smultea et al. 2004; Holst et al. 2005). Dall's porpoise also show little avoidance of seismic survey vessels, but harbor porpoise have been reported moving away from surveys at received levels <155 dB re: 1 µPa (rms) (Calambokidis and Osmek 1998; Bain and Williams 2006). Harbor porpoise have also been shown to be displaced from an area for 24 to 72 hours after being exposed to a cumulative M-weighted Sound Exposure Level (SEL) of 157 dB re: 1 $\mu Pa^2 \cdot s$ from pile driving, another repeated impulsive sound (Brandt et al. 2011). The metric SEL is considered to be biologically realistic in the sense that it incorporates the duration of the noise into the noise metric as well as the received level, unlike rms that only incorporates the received level. No direct measurements of beaked whale responses to impulsive sounds are available, but given their strong avoidance of vessels, it seems likely that they will demonstrate behavioral avoidance at received levels comparable to harbor porpoises.

Pinnipeds: Little data exists on pinniped exposure to seismic pulses and what is available indicates limited reaction or short term localized avoidance (Harris et al. 2001; Miller et al. 2005).

Mustelids: Malme et al. (1984) reported no foraging or behavioral change in Southern sea otters exposed to playbacks of seismic survey noise as close as 900 m. They may however demonstrate local avoidance response to the presence of the survey vessels. Udevitz et al. (1995) report 30% of the sea otters in an area displayed avoidance when a vessel was at 100 m.

2.6 Temporary and Permanent Hearing Loss and Basis for Acoustic Thresholds

Temporary hearing loss (Temporary Threshold Shift: TTS) and permanent hearing loss (Permanent Threshold Shift: PTS) are natural factors of aging and noise exposure. Industrial sounds increase the occurrence of TTS and PTS in humans, which explains government attempts to mitigate this issue with

occupational safety standards that limit human exposure to industrial noise (e.g., OSHA standard 29 CFR 1910.95). Given our shared mammalian ancestry, anthropogenic noise has the potential to cause TTS and PTS in marine mammals as well. PTS has not been demonstrated experimentally in marine mammals for ethical reasons, but a growing body of work has demonstrated TTS onset in several different species of marine mammals caused by noise (e.g. Finneran et al. 2002; Lucke et al. 2009; Finneran et al. 2010). The onset of TTS has generally been defined as a 6 dB difference in hearing sensitivity before versus after the noise exposure. In humans a TTS beyond ~40 dB increases the likelihood of PTS significantly (Kryter et al. 1966) and Southall et al. (2007) therefore use this threshold to estimate the PTS threshold in marine mammals. In chinchillas, the growth rate of TTS beyond the TTS threshold of 6 dB follows a slope of roughly 2.3 dB of additional TTS for every dB increase in impulsive noise (Henderson & Hamernik 1986). Thus, Southall et al. (2007) estimate that PTS from impulsive sound is likely to occur in marine mammals at ~15 dB above TTS onset. This is based on 40 dB TTS (from humans) – 6 dB TTS (TTS onset definition), divided by 2.3 dB TTS per dB of noise exposure (based on growth functions measured in chinchillas). Evidence of TTS onset will be discussed below, but it is important to note that there are a number of acoustic measurements that could be used as PTS/TTS thresholds.

Current NMFS acoustic thresholds for seismic and sounds other than those associated with U.S. Navy activities are based exclusively on dB rms measurements and 1980s estimates of such levels associated with hearing impact as opposed to the direct measurements that have been made subsequent to establishment of the thresholds. As discussed above, the duration over which the rms is calculated can vary significantly for impulsive sounds and the use of this metric for characterizing impulse noise has been questioned (Madsen et al. 2006b). In addition, the duration and impulsive nature of the sound also determine the potential level of PTS. Therefore thresholds based on rms values alone are not very predictive of the likelihood of PTS onset. Using an alternate threshold such as SEL, that incorporates the duration of the noise into the noise metric as well as the received level, is considered to be more biologically realistic. Consequently, Southall et al. (2007) suggest SEL thresholds for TTS onset and consequently the predicted PTS-onset levels they estimated. As has been observed for humans (see Kryter et al. 1996), recent work in marine mammals also demonstrates that TTS onset is not perfectly correlated with received SEL levels either; rather duration appears to have a larger impact on TTS onset than predicted by SEL levels and that recovery time between noise exposure also has an impact on the levels of TTS (Mooney et al. 2009b; Finneran et al. 2010b). At this point, SEL remains a better metric for the prediction of injury onset than rms, but with some demonstrated limitations similar to those observed in predicting TTS dependence on sounds of different exposure level and duration in terrestrial mammals; these threshold metrics will clearly need to be re-evaluated regularly as new data are reported.

There are no direct measurements of TTS/PTS in baleen whales given our inability to test their hearing in the wild. Gedamke et al. (2011) did model the potential for TTS onset for baleen whales. Their model does suggest that TTS (and possibly PTS) onset from seismic surveys is plausible over ranges of several kilometers, however the uncertainty of the inputs to the model (i.e. the extrapolations of noise impacts and hearing in other species) as well as individual variation can have a large impact on the estimates which must at this point be considered speculative (as the authors themselves state). In addition, much of the cumulative SEL is due to the loudest airgun pulses when the animal is closest to the airgun array. Onset of TTS from pulsed watergun/airgun noise has been tested in three species of cetaceans. Finneran et al. (2002) exposed a beluga whale and bottlenose dolphin to watergun noise. The beluga showed TTS

onset at 186 dB re: 1 $\mu Pa^2 \cdot s$ (equivalent to 183 dB M-weighted), however the dolphin did not show indication of TTS at the levels this experiment was able to produce. The level for the beluga was therefore used in the initial Southall et al. (2007) threshold for all cetaceans (198 = 183 + 15). However, Lucke et al. (2009) found a TTS onset in a harbor porpoise exposed to airgun noise at 164 dB re: 1 $\mu Pa^2 \cdot s$, considerably lower than reported by Finneran et al. (2002) for belugas. Whether this difference is due to species or individual difference or a combination of the two is difficult to say. Onset of TTS in pinnipeds in water has been tested for several species (e.g., Kastak et al. 2005), but only with non-pulsed sounds (Southall et al. 2007). As a result, Southall et al. (2007) used the relationship between TTS onset from non-pulsed sounds in belugas and harbor seals (~ 12 dB) to estimate TTS onset levels for pinnipeds in water exposed to pulsed sounds.

2.7 Other physiological effects (stranding, bubble formation)

At extremely close distances, loud sounds could cause physical damage to gas filled chambers (e.g., lungs) in animals. This is caused by the rapid and extreme pressure differentials that make up the sound wave (Gotz et al. 2009). Given many species tendency to move away from very loud sounds, this is unlikely to occur during seismic surveys. Another potential impact of sound on marine mammals is the formation of gas bubbles in the animal's tissues, much like nitrogen bubbles form in human divers and cause decompression sickness. This is based on evidence of lesions in the tissues of beaked whales that stranded after naval sonar exercises (Fernandez et al. 2005). The acoustic pressure itself, a rapid change in depth, or a combination of the two may possibly lead to the formation of bubbles (reviewed in Southall et al. 2007). No evidence links seismic surveys to stranding events or bubble formation in cetaceans.

In addition to the above discussed impacts, noise also has the potential to cause stress and immune responses in marine mammals (Romano et al. 2004; Wright et al. 2007, Rolland et al. 2012). However these are difficult to measure in wild settings and are generally associated with behavioral responses (e.g., startle response, avoidance, etc.). We will therefore utilize behavioral take estimates as discussed above to quantify these effects.

2.8 Echosounders and sub-bottom profilers

Multibeam echosounders typically ensonify a broad swath (150º beam pattern) of the bottom perpendicular to the movement of the vessel, but a very narrow swath (2º beam pattern) in the direction of travel of the vessel. The wide beam pattern is achieved by aiming multiple pulses at successive angles. Sub-bottom profilers are narrow with a cone 30º wide. Maximum source levels and dominant frequencies for echosounders are higher than sub-bottom profilers. Firing rate, source level, and pulse duration can be varied depending on the depth of the area under investigation.

Given the high source levels and mid-frequency (~3-15 kHz) content, there is the potential for an acoustic impact on marine mammals from these sources. Kremser et al. (2005) modeled the potential for TTS in blue, sperm and beaked whales from a Hydrosweep MBES and Parasound SBP. These units have similar frequency and amplitude specification to the units used on the *R/V Langseth*, however they have narrower beam patterns (90º for the MBES and 5º for the SBP). In addition Kremser et al. (2005) modeled ship movement at 12 knots, almost three times the survey speed that will be used by the Langseth. Thus Kremser et al. (2005) estimates of the potential for TTS will likely be underestimates for the potential TTS from the Langseth operations in this study as TTS measurements are based on SEL levels which are dependent on the number of pulses an animal is exposed to. At lower speeds and wider

beam patterns, individual animals will be exposed for longer durations and thus higher SEL levels. However, their models suggest that TTS would only occur at very close ranges to the hull of the vessel (on the order of 100 m or less). Lurton and DeRuiter (2011) also modeled the potential impacts (PTS and behavioral reaction) of echosounders on marine mammals. Based on SEL threshold levels of 198 dB re: 1 μPa^2-s per Southall et al. (2007), they estimated PTS onset at distances of 10 to 100 m generally and possibly 200 m for lower frequency (i.e. 12 kHz) and highest source levels (240 dB re: 1 µPa (rms)). The results from Kremser et al. (2005) and Lurton and DeRuiter (2011) only apply in the cone that is ensonified by the modeled echosounders, meaning that the animal would have to be below the ship to be exposed to these levels. At the same distances, but to the side of the vessel, animals would not be exposed to these levels. This greatly decreases the potential for an animal to be exposed to the most intense signals from MBES or SBP.

It is more likely that animals would be exposed to sound levels from MBES and SBP that cause behavioral responses if they are exposed to the relatively narrow beams of sound from these units. Based on a behavioral response at received levels of 130 dB re: 1 µPa (rms) Lurton and DeRuiter (2011) estimate behavioral response from 4 to 20 km for a 12 kHz MBES with source levels from 210 to 240 dB re: 1 µPa (rms). Studies on captive animals show behavioral responses of beluga whales and bottlenose dolphins to intense 1 second tones at frequencies similar to the MBES and SBP that will be used for this project (Schlundt et al. 2000; Finneran and Schlundt 2004). Likewise harbor porpoise and gray seals have shown behavioral responses to MBES in captivity (Hastie & Janik 2007; Hastie 2007). In wild populations documented reactions have included changes in direction of travel of gray whales, showing that even baleen whales are able to detect sounds from echosounders (in this case 21-25 kHz sounds; Frankel 2005).

3.0 Methods

3.1 Temporal Scope

The time period encompassed by this report is a high energy survey conducted between September potentially through to December. The mid-point of the seismic survey was considered October 20th. For gray whales, the time period of the assessment was extended to Jan 15th (the predicted mid-point date of the southerly migration; Rugh et al. 1999).

3.2 Geographical Scope and Animal Density Estimates

NOAA-NMFS SWFSC scientists (Drs. J. Barlow, J. Carretta and K. Forney) recommended that the most appropriate source for density estimates for most cetaceans in the Project area would be obtainable based on estimates using the online Strategic Environmental Research and Development Program (SERDP) spatial decision support system (SDSS) Marine Animal Model Mapper on Duke's Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) website (http://seamap.env.duke.edu/). This online tool uses predictive habitat modeling based on survey data to estimate densities in a given area of interest (see Barlow et al. 2009). SERDP-SDSS models of cetacean densities are based on SWFSC ship line-transect data collected from 1986 to 2006. Model grid cell resolution is 25 by 25 km.

To use this density estimation tool, the area of interest needs to be defined. Following an interagency meeting discussion and advice from a co-author of the model (Dr. K. Forney, NOAA, pers. comm., 2011), we selected a 50 km buffer (equivalent of 2 grid cells) of the GIS layer provided by PG&E of the offshore Investigation area. The application of a buffer is considered appropriate given the grid square resolution

and large scale habitat input parameters of the model (Barlow et al. 2009) developed for SERDP-SDSS, the spatial area covered by the Investigation area and the movement patterns of most species at the temporal scale of this survey. The resulting buffer zone including the investigation area was approximately 193 km by 81 km, with a total area of 11,362 km^2. This buffer zone area was used simply to estimate mean animal densities per km^2. This contrasts with PG&E using a smaller 4.1-6.2km buffer equivalent to their 160 dB re: 1 µPa (rms) estimate.

The buffered Investigation area GIS layer was loaded into the online tool of the SERDP-SDSS Marine Animal Model Mapper on Duke's OBIS-SEAMAP website. Densities were calculated for cetaceans with the exception of harbor porpoise and gray whales (see below for details). When available the summer Density Model was used for each species. This season encompasses NOAA surveys June through November, however communications with Dr. K. Forney (NOAA, pers. comm., 2011) indicated that most surveys of the study area were undertaken in fall (and therefore relevant to this study period). When the summer Density Model estimate was not available the Stratum Model estimate was used. This estimate has densities for much larger areas (a coarser estimate) and in some cases represent winter estimates (Table 3.1). Beaked whales (*Ziphiidae* sp.) were combined by Barlow et al. (2009) into one grouping termed 'small beaked whales'. All stocks of killer whales were similarly combined. The vast majority of California coastal bottlenose dolphin sightings are within 1km of the shore and densities were therefore confined to this coastal strip (Carretta et al. 1998, Dr. K. Forney, NOAA, pers. comm., 2012, SERDP-SDSS).

Lognormal 90% confidence intervals (termed Upper - Lower) were available for the SERDP-SDSS Density Model outputs. Upper density estimates averaged 1.59 (range 1.4-1.7) times higher for ESA-listed mysticetes and 1.87 (range 1.4-2.9) times higher for odontocetes (Tables 3.1 and 3.11). Lower 90% confidence interval estimates when calculated were close to zero for many species (Table 3.1).

Harbor porpoise (Morro Bay stock) are restricted in their distribution and have been systematically surveyed by NOAA. For harbor porpoise, Dr. K. Forney (NOAA NMFS SWFSC) provided a GIS layer (shapefile) with their distribution and densities (based on stock survey data from Carretta et al. 2009). This layer is split between two density strata; the first with higher density, shoreward of the 50 fathom line (inshore strata), and the second extending from 50 fathoms to ~200m offshore (offshore strata).

Numbers of gray whales, because of the migratory pattern of this species, were calculated by referring to the timing of the southbound migration along the California coast (Malme et al. 1984; Rugh et al. 2001) and the most recent stock assessment (Rugh et al. 1999). From these sources, we estimated the likely start (December 15th) and end (February 15th) dates of the southbound migration, as well as the dates when 10% (December 29th), 50% (January 15th) and 90% (February 1st) of the whales are likely to pass Morro Bay. By fitting a 3rd order polynomial to that cumulative probability distribution we could then estimate the number of whales that would likely have passed the Morro Bay area at various dates into the migration. Before the start of the southbound migration, density of gray whales in the study area was assumed to be zero, though a small number of animals may be potentially present before this date.

Dr. L. Lowry (NOAA-NMFS-SWFSC 2011) provided aerial survey ground (haul-out) counts of the region to estimate minimum population sizes for seals and sea lions. For the compilation of land based counts of pinnipeds, the area from Point Sal to San Simeon was used. Koski et al. (1998) used US Federal research

sighting surveys between 1975-1998 to estimate pinniped densities for a suitable area (termed Stratum 1), defined as <12 nm from shore, north of Point Conception and south of the Piedras Blancas area. Densities for the fall time period were selected.

Sea otter densities were calculated from the USGS Western Ecological Research Center's Spring 2010 survey results (http://www.werc.usgs.gov/ProjectSubWebPage.aspx?SubWebPageID=16&ProjectID=91). These data are available in GIS shapefiles with various density estimates in many polygons along the coast of California. These polygons are roughly 500 meters wide and stretch out to the 60 meter isobath and are further divided between those areas <30m and those >30m. The reported densities in this dataset are averaged over three years and by a 10km moving window to account for spatio-temporal variation in otter movements and survey conditions

Table 3.1 Density estimates of marine mammal species and species groups. Lower and Upper estimates represent 90% lognormal confidence intervals in the SERDP-SDSS Density Model. Also provided are Standard deviation (SD) and Coefficient of Variation (CV) and source of the density estimate. Potential substantial effects analyses were undertaken for those species highlighted in bold (see Sections 3.5 and 3.6 for justification).

Species	Mean	Lower	Upper	SD	Density estimate source
Mysticeti					
California gray whale ***Eshchrichtius robustus***	n/a See text				Malme et al. (1984); Rugh et al. (1999, 2001)
Fin whale ***Balaenoptera physalus***	0.00872	<0.0001	0.0126	0.0044	SERDP-SDSS Density Model – Summer
Humpback whale ***Megaptera novaeangliae***	0.00410	<0.0001	0.0069	0.0023	SERDP-SDSS Density Model – Summer
Blue whale ***Balaenoptera musculus***	0.00472	<0.0001	0.0077	0.0026	SERDP-SDSS Density Model – Summer
Minke whale ***Balaenoptera acutorostrata***	0.00028				SERDP-SDSS Stratum Model – Winter
Northern right whale *Eubalaena japonica*	0.00006				SERDP-SDSS Stratum Model – Winter
Sei whale *Balaenoptera borealis*	0.00009				SERDP-SDSS Stratum Model – summer
Odontoceti					
Short-beaked common dolphin ***Delphinus delphis***	0.61420	0.0017	0.9373	0.3199	SERDP-SDSS Density Model – Summer
Long-beaked common dolphin ***Delphinus capensis***	0.01890	0.0180	0.0550		SERDP-SDSS Stratum Model – Summer
Small beaked whale species (combined) ***Ziphiidae* sp.**	0.00310	<0.0001	0.0048	0.0015	SERDP-SDSS Density Model – Summer
Harbor porpoise (Morro Bay stock - inshore area)	0.95900	1.805	0.510		Carretta et al. (2009)

Phocoena phocoena					
Harbor porpoise (Morro Bay stock - offshore area) ***Phocoena phocoena***	0.06200	0.164	0.023		Carretta et al. (2009)
Dall's porpoise ***Phocoenoides dalli***	0.02892	0.0001	0.0486	0.0150	SERDP-SDSS Density Model – Summer
Pacific white-sided dolphin ***Lagenorhynchus obliquidens***	0.06511	0.0001	0.0996	0.0334	SERDP-SDSS Density Model – Summer
Risso's dolphin ***Grampus griseus***	0.02804	0.0001	0.0548	0.0174	SERDP-SDSS Density Model – Summer
Northern right whale dolphin ***Lissopelphis borealis***	0.04083	0.0001	0.0585	0.0203	SERDP-SDSS Density Model – Summer
Striped dolphin *Stenella coeruleoalba*	0.00379	<0.0001	0.0071	0.0021	SERDP-SDSS Density Model – Summer
Bottlenose dolphin – California coastal ***Tursiops truncatus***	0.3612				SERDP-SDSS Stratum Model – Year round
Sperm whale ***Physeter macrocephalus***	0.00069	<0.0001	0.0011	0.0003	SERDP-SDSS Density Model – Summer
Short-finned pilot whale *Globicephala macrorhynchus*	0.00031				SERDP-SDSS Stratum Model – Summer
Killer whale (all stocks) *Orcinus orca*	0.00071				SERDP-SDSS Stratum Model – Summer
Pinnipedia					
Harbor seal ***Phoca vitulina richardsi***	0.02336			CV0.94	Koski et al. (1998) – Fall Stratum 1
Elephant seal *Mirounga angustirostis*	0.15493			CV0.68	Koski et al. (1998) – Fall Stratum 1
Northern fur seal *Callorhinus ursinus*	0.03095			CV0.65	Koski et al. (1998) – Fall Stratum 1
California sea lion ***Zalophus californianus***	1.50039			CV0.25	Koski et al. (1998) – Fall Stratum 1
Guadalupe fur seal *Arctocephalus townsendi*	No data See text				NCCOS (2007)
Northern (Steller) sea lion *Eumetopias jubatus*	No data See text				NCCOS (2007)
Mustelidae					
Southern sea otter ***Enhydra lutris nereis***	1.59332				USGS WERC Otter Survey 2010

3.3 Impact Assessment Methodology

Project stressors may have direct impacts (caused by the action and occurring at the same time and place), indirect impacts (caused at a later time or farther removed) or may cause both due to different mechanisms. Potential project stressors include acoustic, entanglement, oil contamination, habitat alteration and vessel collision, most of which have both direct and also indirect impacts. For each of

these stressors we evaluate potential impacts on key marine mammal species by comparing primary stressor characteristics with pre-determined thresholds. Using this systematic methodology, we simply aim to use threshold criteria to predict a level of significance for identified stressors, flag any eventual potential high impacts on marine mammal species and provide mitigation recommendations.

We present the basic flow of this assessment process in this section, with more details provided in subsequent sections. Following scoping of the Project's stressors, a review of the biological context and potential susceptibility of those species that may be locally present during the Project's proposed timeline (September to December) was carried out based on Figure 3.1. Key biological context criteria include seasonal occurrence and relative density, population demographics, listed status, habitat use for critical life functions, habitat suitability and known/presumed susceptibilities to the key stressors identified. The review aimed at identifying those recipient species ecologically sensitive and present at densities sufficient to lead to potential significant adverse effects. After identifying the stressors and these key recipients, we use the derived severity and impact matrices to identify potential significant impacts (those with high impact ratings), and synthesize the results into an adverse effects conclusion, given the individual species biological context.

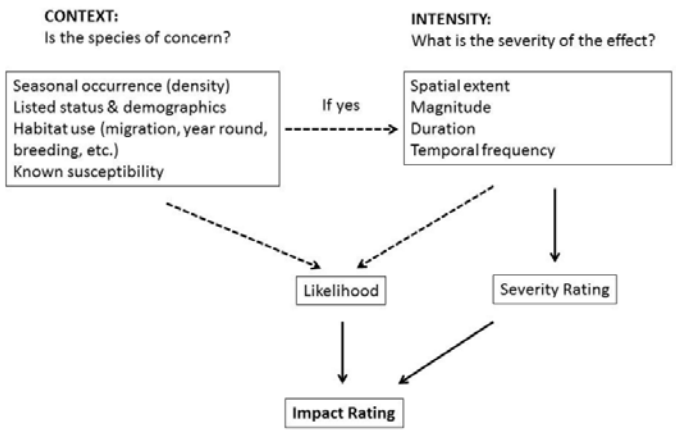


Figure 3.1. Outline of impact assessment methodology.

3.3.1. Severity ratings

The severity of an impact is estimated based on the intensity of several key factors of the stressor. Components considered to affect severity are magnitude, geographical extent and temporal duration and frequency.

NMFS (NOAA Fisheries) has set two statutory thresholds for stressors on marine mammals; Level A and Level B harassment which can lead to a 'take'. A Level A take occurs when the stressor causes an injury or mortality in the animal whereas a Level B take occurs when a significant behavioral change is caused by the stressor. In terms of acoustic injury from any sound type (Level A), NMFS relies on the HESS (1999) panel assessment based on information available at that time (prior to most of the existing literature on marine mammal TTS). These Level A thresholds are 180 dB re: 1 µPa (rms) for all cetaceans and 190 dB re: 1 µPa (rms) for all pinnipeds. Level B is presently set by NMFS at 160 dB re: 1 µPa (rms) for impulsive sound sources and 120 dB re: 1 µPa (rms) for continuous sound sources.

We use these two regulatory distinctions in our analysis to estimate levels of potential impact for acoustic stressors based on both Level A and Level B harassment. The take estimates for acoustic thresholds rely on calculating the amount of area ensonified by the acoustic stressor, and identifying areas where the thresholds are exceeded. We have assumed that any Level A or B harassment would result in a take. These takes are used to define the magnitude level.

Calculating an acoustic take requires a number of important assumptions, including using appropriate density estimates and threshold criteria. This report estimates Level A and B takes using a dual threshold criteria approach. The two sets of acoustic threshold criteria vary across the metric selected, whether hearing sensitivity is taken into account and the threshold levels used. Summary details are provided below in Table 3.2, with full justification provided in Section 3.7.

Table 3.2 Summary of dual threshold criteria for estimating acoustic takes and steps for determining magnitude of effect.

Threshold Level	**Dual criteria term**	**Key metric**	**M-Weighted for hearing sensitivity**	**Threshold information**	**Steps to determine Magnitude level**
Level A	NMFS rms[1]	Root mean square (rms)	No	NMFS levels Pinnipeds: 190dB re: 1 µPa Cetaceans: 180 dB re: 1 µPa	Compare take with residual Potential Biological Removal (Table 3.3)
Level A	Injury SEL	Cumulative 24 hour Sound Exposure Level (SEL)	Yes	Southall et al. (2007) levels, but revised SEL for low and high frequency cetacean groupings (Table 3.8)	Compare take with residual Potential Biological Removal (Table 3.3)
Level B	NMFS rms[1]	Root mean square (rms)	No	NMFS Levels All species (pulsed): 160 dB re: 1 µPa	Compare take with regional minimum population (Table 3.3)
Level B	Probabilistic Disturbance rms	Root mean square (rms)	Yes	Varied response at range of thresholds, varying by species sensitivity and context (Table 3.9)	Compare take with regional minimum population (Table 3.3)

[1] Two take estimate approaches were calculated for NMFS criteria: using the 'Minimum' area ensonified (which excludes all areas of overlap and represents the minimum number of individual takes) and using the 'Maximum' area ensonified (which includes all overlap areas and therefore includes repeated takes of the same individual).

One goal of this review is to estimate potential levels of acoustic 'take' using the dual criteria and put them into context with regards to magnitude of the effect at the population level. A precautionary or conservative approach was adopted; both by setting magnitude levels lower for listed species, as well as

in our metrics for comparison. Many marine mammals, especially cetaceans rely upon hearing for critical life history functions (such feeding, breeding and predator avoidance; Richardson et al. 1995); therefore permanent hearing loss may, in some cases, indirectly lead to mortality or a removal through reduced fecundity (NRC 2005). Acoustic takes are often compared to the percentage of the local population affected (see NSF 2011). To assess the magnitude of the Level A effects on biological resources relative to the population, we however used Potential Biological Removal (PBR) as the most appropriate metric to evaluate the relevance of potential mortality/injury effects. This tacitly assumes, as a worst case approach, that all Level A takes may cause the eventual equivalent of mortality (whether indirectly or directly) of an individual. This assumption overestimates the potential significance of Level A acoustic takes and should be considered precautionary. The magnitude of Level B takes were assessed using the percentage of the minimum stock population affected. The use of the minimum stock population is also precautionary.

The Marine Mammal Protection Act (MMPA), as reauthorized in 1994, defined PBR as, "...the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population." PBR was intended to serve as an upper limit guideline for fishery-related mortality for each species. The MMPA also provides some rationale for establishing certain numerical thresholds for the magnitude of mortality relative to PBR. Section 118 of the MMPA requires NMFS to classify fisheries according to their relative levels of mortality for each marine mammal stock (16 U.S.C. 1387 (c)(1)). Fisheries that cause mortality of a marine mammal stock totaling 10 percent of PBR or less are classified as Category III fisheries and are not required to register with NMFS or obtain authorizations for incidental take (50 CFR 229.2). In addition, the MMPA established a requirement that the level of incidental mortality and serious injury of marine mammals in fisheries be reduced to “insignificant levels approaching a zero rate”, which is commonly referred to as the Zero Mortality Rate Goal (ZMRG). To implement the MMPA, NMFS defined the insignificance threshold for fisheries related mortality, the ZMRG, as being 10 percent of PBR for the stock of marine mammals (69 FR 43338). Fisheries that cause mortality equal to or exceeding 50 percent of residual PBR for a marine mammal stock are classified as Category I fisheries and are required to register with NMFS, follow a take reduction plan, and may be required to carry marine mammal observers on board to monitor take. Residual PBR estimates are termed PBR minus the reported annual anthropogenic mortality estimate.

In this assessments, the magnitude of Level A takes are defined as; Level A takes less than or equal to 10 percent of residual stock PBR will be considered ‘negligible’ magnitude; between 10 and 50 percent of residual PBR will be considered ‘Low’ magnitude; between 50 to 100 percent of residual PBR will be considered ‘moderate’ and greater than 100 percent of residual PBR will be considered as ‘High’ magnitude (see Table 3.3).

Defining magnitude for disturbance (Level B) effects is considered particularly subjective. Negligible impacts are identical to those presented in the NSF (2011) programmatic review. For the purpose of defining significance in the Environmental Impact Report (EIR) for this proposed Project, CSLC established thresholds that consider a level B harassment to one special status species as significant. For the purpose of this analysis, this report defines Level B magnitude as follows: Less than 1 ESA-listed species and less than 5 percent for a non-listed species minimum population is considered negligible (Table 3.3). Low magnitude, extends from one ESA-listed species to <1.25 percent of the minimum regional population, and 5-15 percent for a non-listed species minimum regional population. High

magnitude extends greater than 2.5% of the ESA-listed species minimum regional population and above 25 percent for a non-listed species regional minimum population (see Table 3.3). for example, using these values, a high magnitude Level B take would correspond to the harassment of 47 humpback whales (California/Oregon/Washington stock), 51 blue whales (Eastern north Pacific stock) or 370 harbor porpoise (Morro Bay stock).

The geographical extent allows for the categorization of the spatial extent of the stressor. This is an important distinction since some stressors will not extend beyond the immediate vicinity (Local) of the Project area, while others may extend to Regional, or State-wide levels. The duration and temporal frequency components provide measures of the temporal aspect of the stressor. Duration denotes the longevity of the effect caused by the stressor while temporal frequency denotes how often the stressor events take place. 'Short-term' refers to a temporary effect that last up to one month and the affected animals or resource reverts back to a 'normal' condition. 'Long-term' refers to more permanent effects that last beyond one season up to years and from which the affected animals or resource never revert back to a 'normal' condition. Moderate-term is defined as between 1-3 months with effects potentially permanent (Table 3.3). Duration levels were designed to highlight those stressors that may endure for the full length of the proposed Project versus ones lasting shorter time periods. For clarification, the pathway of impact (direct or indirect) has a duration component to it, but should not be confused with duration of the effect. An indirect effect may start later than the initial stressor, but that does not determine how long the effect lasts. The pathway describes the onset of the stressor, the duration how long the effects of the stressor last. Frequency levels range from continuous to isolated (may occur one or two times), with intermittent defined as an intermittent but repeated action (see Table 3.3).

Table 3.3 Descriptions of the levels within four intensity components used to rate severity

Geographical Extent:

State-wide	Effects extend outside regional boundary, but within state setting.
Regional	Effects likely to extend outside of project boundary to regional setting.
Local	Effects likely to be limited within project boundary.

Magnitude (Mortality/Injury/Level 'A' take):

High	>100% of stock population residual PBR affected
Moderate	50-100% of stock population residual PBR affected
Low	10-50% of stock population residual PBR affected
Negligible	<10% of stock population residual PBR affected

Magnitude (Disturbance/Level 'B' take):

High	>25% of regional non-listed species minimum population / >2.5% ESA-listed regional minimum population
Moderate	15-25% of regional non-listed species minimum population / 1.25-2.5% of ESA-listed regional minimum population
Low	5-15% of regional non-listed species minimum population / 1 ESA-listed animal and <1.25% of ESA listed minimum population
Negligible	<5% of regional minimum population / <1 ESA listed animal

Duration:

Long-term	refers to more permanent effects that may last for more than 3 months (a season) to years and from which the affected animals or resource never revert back to a "normal" condition
Moderate-term	refers to a temporary effect that lasts 1 to 3 months and the affected animals or resource may revert back to a "normal" condition.
Short-term	refers to a temporary effect that lasts from days to one month and the affected animals or resource revert back to a "normal" condition.

Frequency:

Continuous	Effects continuous.
Intermittent	Effects intermittent, but repeated.
Isolated	Effects confined to one or two periods.

Intensity component levels, once established, were used to determine a severity rating using a matrix approach depicted below in Table 3.4. Severity ratings were described as High, Medium, Low or Negligible.

Table 3.4 Severity rating matrix methodology.

Magnitude	Extent	Temporal Duration/Frequency	Severity Rating
High	Regional	Any	High
Moderate	Regional	Any except Short-term/isolated	
High	Local	Any	
Any	State-wide	Any	
Moderate	Regional	Short-term/isolated	Medium
Moderate	Local	Any	
Low	Regional	Any	
Low	Local	Any except Short-term/ intermittent or isolated	
Low	Local	Short-term/Intermittent or Isolated	Low
Negligible	Any	Any	Negligible

3.3.2 Impact Ratings

The final impact rating is then determined using a matrix combination of severity rating and likelihood of occurrence depicted below in Table 3.5. The likelihood of occurrence component serves to assess whether the potential effects are plausible or just speculative. High likelihood is described as those that could arise from reasonable or demonstrated mechanisms and the probability of those mechanisms arising from the alternatives is very likely or greater than 50 percent. Medium likelihood is described as possible or probable, Low likelihood is described as unlikely and Very low likelihood is described as very unlikely. This does not imply that we will perform a formal probability calculation but, that in our professional judgment, the probability of the effect occurring is more likely than not. Stressor component levels are quantitative for some sources and qualitative for others, necessarily requiring the analyst to make a judgment about where a particular effect falls, or make assumptions about the likelihood of an effect after mitigation measures are applied.

Table 3.5. Impact rating matrix methodology

Severity Rating	Likelihood of Occurrence	Impact Rating
High	High or Medium	High
High	Low	Moderate
Medium	High or Medium	
Low	High	
High	Very Low	Low
Low	Medium	
Low	Low	
Medium	Low or very Low	
Low	Very Low	Negligible
Negligible	Any	

It is important to recognize that this impact assessment methodology is designed to highlight those species and stressor combinations with potentially high impact. Judging whether the impact is potentially significant at the stock or local population level also requires integration of information on its capacity to withstand the impact, taking into account whether the impact might occur during a sensitive or critical part of the year, within potentially important habitat and the assumed flexibility of the species to adjust to disturbance. Perhaps of equal importance, given the uncertainty levels in many components, is to ensure consideration is given to potential variability, for example, in predicted animal densities, behavioral response and the environmental factors that may influence temporal and spatial distribution.

3.4 Scope of potential Project stressors

A review of the proposed Project application materials provided resulted in the following potential stressors and sources being identified (Table 3.6). Stressors considered to have both direct and indirect pathways are identified individually for use in the impact assessment. Level B harassment is considered an indirect stressor due to the pathway mechanism of potential effects.

Table 3.6 Potential Project stressors[1] identified in scoping process

Stressor	**Source**	**Possible pathway/mechanism**
Acoustic	*Air-gun array*	*Level A harassment (direct)*
		Level B harassment (indirect)
		Secondary prey effects (indirect)
Acoustic	*Mitigation (single) air-gun*	*Level A harassment (direct)*
		Level B harassment (indirect)
		Secondary prey effects (indirect)
Acoustic	Echo-sounder and profiler	Level A harassment (direct)
		Level B harassment (indirect)
Acoustic	*On-shore seismic sources*	*Level B harassment – land (indirect)*
		Level B harassment – water (indirect)
Acoustic	*Vessels (propeller/engine)*	*Level B harassment (indirect)*
Acoustic	*Survey aircraft*	*Level B harassment (indirect)*
Entanglement	Air-gun/hydrophone strings	Injury/Mortality (direct)
Entanglement	Geophone offshore strings	Injury/Mortality (direct)
Oil contamination	*Vessels*	*Injury/Mortality (direct)*
		Life function effects (indirect)
Habitat alteration	*Use of offshore geophones*	*Life function effects (indirect)*
Vessel interaction	*Vessels*	*Injury/Mortality (direct)*
		Non-acoustic disturbance (indirect)

[1] Where a stressor has potentially different pathways or mechanisms of effect they have been partitioned. Stressors highlighted in italics have explicit or incidental forms of APMs.

Direct effects or wide-scale indirect effects should be considered a priority for impact assessment. Overall, acoustic harassment (due to geographical and temporal scale and likelihood) is considered as the primary stressor for the proposed activity. The Draft Biological Assessment (Appendix A of the Application) highlights various Applicant Proposed Measures (APMs) to reduce the impact of four stressors: Acoustic noise, oil spill, vessel collision and on-land geophone placement. In addition, the *R/V Langseth* has a quiet propulsion system (PG&E 2011b) and will not use bow thrusters during seismic

operations. For the majority of time, all vessels will be moving at relatively slow speeds and together these are considered incidental mitigation measures with respect to subsequent level B acoustic disturbance from vessels.

A negligible magnitude and low likelihood assessment (negligible impact rating) were determined for the following stressors: Acoustic effects of on-shore seismic sources and Habitat alteration by placement and retrieval and use of offshore geophones. These stressors were not assessed further in this technical report but are addressed in the EIR.

3.5 Estimation of acoustic Impact (Ensonified area)

3.5.1 Preliminary scoping

The estimation of acoustic impact was undertaken first in a scoping assessment, which aimed to determine which species would be expected to exceed a NMFS level B minimum take of at least 1 individual (thus meeting CSLC Significance threshold a), but also contribute in identifying 'candidate' species for a full acoustic take analysis and a comprehensive consideration of potential substantial adverse effects by the proposed Project (see section 3.6 for detailed selection criteria). The area of Alternative 2 (overall the largest noise footprint, 1,935 km^2) predicted to be ensonified to received levels of 160 dB re: 1 µPa (rms) threshold was estimated and based on this area, mean species density estimates exceeding 0.00051 km^2 would be expected to exceed a NMFS level B take of at least 1 individual (CSLC Significance threshold a). The Project area footprint in comparison is lower at 1757 km^2.

3.5.2 Full acoustic take analysis

The project has multiple sources of acoustic stressors. The airguns are fired concurrently with the use of the echosounder and sub-bottom profiler, therefore a noise footprint (ensonified area) that **combined** all the main active acoustic survey sources was calculated. For rms metrics, this entailed using the source with the greatest acoustic radii (typically the air-gun array, but often the echosounder during the turns), which were calculated by Jasco Applied Science for nine representative depth/bottom types (Appendix I). For SEL, this entailed calculating the 24hr cumulative SEL total by combining the values calculated for each instrument. Combined source takes were calculated for Level A and B using the dual criteria thresholds and modified to take into account of various factors such as depth preferences, behavioral response and Project APMs. Takes were converted to magnitude levels (Table 3.3) and severity and impact ratings determined as described above. For the main acoustic take analyses, three different animal density scenarios (termed Base, Upper and Potential) were modeled, aiming to reflect uncertainties in model-predicted density estimates. Combined active acoustic source takes were calculated and impact ratings determined for the proposed Project and the three alternatives. Adverse effects conclusions were generated using these acoustic impact ratings, as well as ratings based on the remaining stressors. The newly developed noise criteria thresholds (Injury SEL and Probabilistic Disturbance rms) were preferentially weighted in this final population level assessment.

3.6 Scope of individual effects and selection of candidates for substantial adverse effects review

Section 4.4.4 within the EIR document provides a summary of the species of marine mammal that may be encountered within the Project area. Within the EIR's biological resource section, life history information has been compiled, including minimum and best population estimates for the relevant stock, population trajectory, PBR and residual PBR estimates and hearing sensitivities. In this report, identifying 'candidate' species for consideration of potential substantial adverse effects by the CCCSIP Project were based on a qualitative integration of the following broad criteria:

Firstly, protected status, population and PBR level. PBR is considered a precautionary metric to assess possible population-level effects. The PBR level is the product of the following factors: the minimum population estimate of the stock; one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size; and a recovery factor of between 0.1 and 1.0 (depending on the stock status). PBR levels used in the acoustic take assessment are 'residual' PBR estimates (i.e., reported annual anthropogenic mortality estimate removed) and are based on latest NMFS NOAA/USFWS reports for the relevant local stock area/population as follows;
http://www.nmfs.noaa.gov/pr/pdfs/sars/po2011_draft_summary.pdf,
http://www.fws.gov/ventura/species_information/so_sea_otter/SSO_SAR_2008_FINAL.pdf,
http://www.nmfs.noaa.gov/pr/pdfs/sars/ak2009.pdf,
http://www.nmfs.noaa.gov/pr/pdfs/sars/ak2010whgr-en.pdf.

Secondly, habitat use, relative density and habitat suitability assessment. This assessment draws upon key biological resource information (including section 4.4.4 of the EIR) about the occurrence, level and type of use (e.g., breeding, feeding, migrating, etc.), and seasons of use by marine mammals in the study area (including information from local field scientists). The justification of including these thresholds was two-fold. Firstly, it aimed to identify those protected status populations with very low likelihood of occurring in the Investigation area, due to very low sighting rates and/or habitat preferences. Secondly, it aimed to provide a means to identify those species without protected status, but that may be more vulnerable to impacts for a variety of factors. For example, those populations/stocks that are known to be resident in the south Central California region (e.g., Morro Bay Stock of harbor porpoises, Southern sea otters), those species considered to be a species with potential for high relative seasonal density (e.g., Common dolphin, Risso's dolphins, California sea lions) or known to use the Investigation area as a migratory pathway (e.g., gray whales). Finally, consideration was also given to notable regional bathymetric features (for example submarine canyons) that might imply potential for preferred habitat use by typically low density species. The time period September to December was used as a temporal cut-off in the seasonal presence assessment.

Thirdly, the known or inferred sensitivity of a particular marine mammal species to low-frequency sounds from airguns (e.g., mysticetes, see section 2, HESS 1999) or known high sensitivity to anthropogenic noise (e.g., harbor porpoise, Beaked whales - see section 2) was included in the scoping review.

A synopsis of the information needed to evaluate these three broad thresholds is included in the column 'summary of biological context' in Table 3.7 below.

Table 3.7. Summary of biological context and preliminary acoustic effects scoping review. A detailed biological resources review is presented in Section 4.4.4 of the EIR document.

Common Name	**Summary biological context** [1]	**Preliminary individual and population acoustic effects scoping review**	**Candidate for full take analysis**
Mysticeti			
California gray whale	Eastern North Pacific Stock. Migration route for majority of best population estimate 19,126 individuals. Southward transit through investigation area starts mid-December and peaks mid-January. Majority of population likely to travel within 3 nautical miles of coast and pass through study area in <24 h. (Rugh et al. 1999, 2001). Feeding limited. Localized avoidance to seismic exploration sound indicated (Malme et al. 1984).	Potential Biological Removal = 360. Anthropogenic mortality = 127. Estimated NMFS Minimum Level B take >1 individual only if survey delayed past mid-December. Scale of impact on population proportional to extent of delay, with cause for concern if survey continues past late December. **Quantification of project and acoustic impacts on population required.**	Yes
Fin whale	**Endangered**. California/Washington/Oregon stock best population estimate 3,044. Seasonally present from continental slope to offshore. Inter-annual density variability documented (Peterson et al. 2006). Key prey is krill and small fish, seasonal movement unclear but lower density in winter and spring. Vocal behavior September - February observed in Northern California may indicate breeding activity. Changed vocal behavior (cessation) in response to seismic exploration sounds. Mysticeti show localized avoidance to seismic exploration sound.	Potential Biological Removal=16. Annual strike related mortality= 1. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes

Humpback whale	**Endangered.** California/Washington/Oregon stock best population estimate 2,043. Seasonally present (non-breeding) from inshore to slope with summer to October peak. Green et al. (1992 cited in Calambokidis et al. 2008) reported that encounter rates off Oregon/Washington in the summer were highest on the slope, and in the fall, they were highest on the shelf. Late-fall southerly migration route. Low density by mid-November. Inter-annual density variability documented (Calambokidis et al. 2004, 2008; Peterson et al. 2006). Key prey is both krill and small fish. Humpback whales are often sighted singly or in groups of two or three, but while in their breeding and feeding ranges, they may occur in groups of up to 15. Foraging aggregations have been observed in the vicinity of Morro Bay, Avila Beach and Pismo Beach in some years (K. Forney, NOAA, pers. Comm. 2011). Church Rock documented foraging hotspot (K. Winfield, Sub Sea Tours, pers. Comm. 2011). Changed vocal behavior (cessation) in response to seismic exploration sounds. Mysticeti show localized avoidance to seismic exploration sound.	Potential Biological Removal=11.3. Anthropogenic mortality=3.6. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes

Blue whale	**Endangered**. Eastern North Pacific stock best population estimate 2,497. Seasonally present (non-breeding) from shelf (typically >80m depth, J. Calambokidis, Cascadia, 2011) to offshore. Peak density in summer months at around 200 m depth (J. Calambokidis, Cascadia, pers. Comm., 2011), typically with decreasing density from September through November. The Northeast Pacific stock of blue whales may be the largest remnant population in the world. Feed on dense concentrations of krill which make them vulnerable to perturbations in prey abundance. Blue whales travel 100s of km between foraging patches (Bailey et al. 2010) and respond to environmental variation by feeding further north rather than within smaller prey patches. Area considered a transit route between Santa Barbara basin and Monterrey area (typically northwards in mid-summer and southwards in fall). Migratory movement south towards Baja California and the Costa Rica Dome region appears to start in November (Bailey et al. 2010), with low local area density by mid-November. Blue whales usually occur alone or in small groups. High inter-annual density variability documented (Calambokidis et al. 2004, 2008; Peterson et al. 2006). Time on surface increases at night (Bailey et al. 2010). Changed vocal behavior (increased call rates) in response to seismic exploration sounds. Mysticeti show localized avoidance to seismic exploration sound.	Potential Biological Removal=3.1. Annual strike related mortality= 1. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean area density estimates (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes

Minke whale	California/Washington/Oregon stock best population estimate 478. Habitat selection variable. Seasonally present, with breeding in winter. The SERDP-SDSS winter stratum density estimate for minke whales was 0.000276 km^2, but this was not corrected for missed diving animals. However, unpublished NOAA density estimates (based on 1990-1997 uncorrected survey data) yielded 0.0071 animals per km^2 (K. Forney, NOAA, pers. comm., 2011).	Potential Biological Removal=2. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and unpublished NOAA species density estimate (K. Forney, NOAA, 2011). **Quantification of project and acoustic impacts on population required.**	Yes
North Pacific right whale	**Endangered.** Eastern North Pacific stock. The likelihood of a North Pacific right whale being present in the Investigation area is considered extremely low. There is no reliable population estimate, although the population in the eastern North Pacific Ocean is considered to be very small, perhaps in the tens to low hundreds of animals. Multiple years of systematic aerial and ship-based surveys for marine mammals off the western coast of the U.S. has documented seven sightings of right whales between 1990-2000, with most whales assumed to be in Alaskan waters (Wade et al. 2011). The SERDP-SDSS winter stratum density estimate for Right whales was 0.000061 km^2. Mysticeti show localized avoidance to seismic exploration sound.	**Chance of any North Pacific right whales appearing near the Project site is extremely remote. Likelihood of individual effects (including NMFS level A or B take) considered remote due to extremely low density prediction.** **Project is not likely to adversely affect North Pacific right whales.**	No
Sei whale	**Endangered.** Eastern North Pacific stock best population estimate 126. Most often found in deep, oceanic waters of the cool temperate zone. Sei whales are now rare in California waters, with just nine confirmed sightings of sei whales made in California, Oregon and Washington waters during extensive ship and aerial surveys between 1991- 2008. Sightings were mainly in deeper, offshore waters of Northern California and Oregon, with no confirmed sightings made within 200 km of the Investigation area (Carretta et al. 2011). The SERDP-SDSS winter stratum density estimate for sei whales was 0.000086 km^2. Mysticeti show localized avoidance to seismic exploration sound.	**Chance of any sei whales appearing near the Project site is extremely remote. Likelihood of individual effects (including NMFS level A or B take) considered remote due to extremely low density prediction.** **Project is not likely to adversely affect sei whales.**	No

Odontoceti			
Short-beaked common dolphin	California/Oregon/Washington stock best estimate 411,211. This species is the most abundant cetacean off California and occurs from the coast out to at least 500 km offshore; off central California, it mostly occurs well offshore, over slope habitats and beyond. Sightings from the NCCOS (2007) central California data set, 2003, include 35 sightings of 2,255 common dolphins, mostly seaward of the 200 m contour. Occurs in large groups, sometimes very large (~2500, K. Forney, NOAA, 2011). Padre (2011) sighted 144 Common dolphins. Frequent occurrences of Common dolphins entering safety zone of seismic surveys (Calambokidis et al. 1998).	Potential Biological Removal=3,440. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Long-beaked common dolphin	California stock best estimate 27,046. The Long-beaked common dolphin partially overlaps some of the distribution of the Short-beaked common dolphin; the Long-beaked common dolphin occurs mostly off southern California and Baja California generally within about 90 km of the coast. Can occur in large groups (300-600, K. Forney, NOAA, 2011). Padre (2011) sighted 144 Common dolphins. Frequent occurrences of Common dolphins entering safety zone of seismic surveys (Calambokidis et al. 1998).	Potential Biological Removal=164. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Small beaked whale sp.	Combined best estimate for California/Oregon/Washington stocks 4,074. Due to the rarity of sightings, species of Beaked whales in the study area have been grouped. Data in the NCCOS (2007) central California data set (1980-2003) include sightings of Baird's beaked whale (*Berarduis bairdii*), Cuvier's beaked whale (*Ziphius cavirostris*), and unidentified beaked whale (*Mesoplodon* spp.). Baird's beaked whales are distributed along continental slopes and throughout deep waters of the North Pacific; Cuvier's beaked whale is the most commonly sighted beaked whale in US West Coast waters (Carretta et al. 2011). Mesoplodont beaked whales are five different species are distributed along continental slopes and throughout deep waters in the North Pacific Ocean (Koski et al. 1998). Beaked whales considered to have high sensitivity to anthropogenic sound (Tyack et al. 2011).	Combined species Potential Biological Removal=25. NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean area density estimates (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes

Harbor porpoise	Morro Bay stock estimated at 2,044. Resident, near-shore species with limited range. A total of 1,776 were estimated in waters <50 fathoms (91m), with 268 estimated offshore (<200m, Carretta et al. 2009). Respective densities are 0.959 $km^2$and 0.062 km^2. Population increasing since gill net restrictions imposed in recent years. Typically occur in small groups. The Investigation area encompasses a significant portion of the range of this stock. Spring and summer births, with breeding likely in fall. Padre (2011) documented 39 local sightings. Harbor porpoise are considered to have high sensitivity to seismic exploration sound (Lucke et al. 2009).	Potential Biological Removal=15. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Carretta et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Dall's porpoise	California/Oregon/Washington stock best estimate 42,000. The NCCOS (2007) central California data set (1980-2003) contained 818 sightings, the most commonly sighted (number of sightings) of the small cetaceans and was present during all seasons. Overall density distribution of Dall's porpoise was widespread over the shelf, slope, and deep ocean habitats (mainly >100m). The distribution of Dall's porpoise is highly variable among years/seasons and appears to be affected by oceanographic conditions.	Potential Biological Removal=257. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Pacific white-sided dolphin	California/Oregon/Washington stock best estimate 26,930. Pacific white-sided dolphins are found in cold, temperate waters of the North Pacific Ocean from North America to Asia. They become most abundant in shelf waters off southern California from November to April and then off Oregon and Washington in May. Population may be migrating seasonally from the south to the north in the eastern North Pacific. Generally found in deeper/more offshore water, but can be seen fairly close to shore (Koski et al. 1998). Risso's, Northern right whale dolphin and Pacific white-sided dolphin often seen together in groups.	Potential Biological Removal=193. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes

Risso's dolphin	California/Oregon/Washington stock best estimate 6,276. The distribution of Risso's dolphin off California, Oregon, and Washington is highly variable, apparently in response to seasonal and inter annual oceanographic changes (Forney and Barlow, 1998). Dolphins found off California during colder water months are thought to shift northward into Oregon and Washington as water temperatures increase in late spring and summer. Near-shore year-round species locally and most often sighted cetacean by Padre (2011) with 364 sightings. Risso's, Northern right whale dolphin and Pacific white sided dolphin often seen together in groups. Seen in small to moderate groups (1-250) but also in large schools (Koski et al 1998).	Potential Biological Removal=39. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Northern right whale dolphin	California/Oregon/Washington stock best estimate 8,334. Generally considered offshore, but in also regionally seen fairly close to shore. Padre (2011) reported 10 sightings. Risso's, Northern right whale dolphin and Pacific white sided dolphin often seen together in groups.	Potential Biological Removal=48. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Striped dolphin	California/Oregon/Washington stock best estimate 10,908. Abundant in eastern tropical Pacific waters where they form large mixed schools. Typically sighted within about 100-300 nautical miles from the coast.	Potential Biological Removal=82. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). Offshore and wide-ranging species with relatively low densities in inshore waters. **Project may affect, but is not likely to adversely affect Striped dolphin**	No

Bottlenose dolphin – California coastal and offshore stocks	The California coastal stock best estimate is 323. This stock occurs mostly off southern California and into Mexican waters, but moves northward into central California during warm-water periods (Carretta et al. 2011). The Investigation area is considered within the northern part of the range. Found largely with 1km of shore and surveys by Carretta et al. (1998) found 48.8 animals per 100 km of coast. Groups of 13+ animals were recorded in the Investigation area (NCCOS 2007). The California/Oregon/Washington offshore stock has been sighted mostly in the southern California Bight; north of there the sightings are well offshore.	Potential Biological Removal (California coastal) =2.4. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required (California Coastal).**	Yes
Sperm whale	**Endangered** California/Oregon/Washington stock best estimate 971. Sperm whales are widely distributed across the entire North Pacific, and although seasonal movements of sperm whales in the North Pacific are unclear, it is thought that males move north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands, while females and young sperm whales usually remain in tropical and temperate waters year-round (Angliss and Outlaw, 2007). Off California, sperm whales occur year-round (Barlow et al. 1997), with peak abundance from April through mid-June and from end of August through mid-November. Mostly over the slope and deep ocean habitats. May delay foraging due to seismic exploration sound.	Potential Biological Removal=1.5. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Short-finned pilot whale	Best estimate for California/Oregon/Washington stock 760. Considered rare and distributed offshore.	Potential Biological Removal=4.6. **Likelihood of individual effects (NMFS level A or B take) considered remote due to extremely low density prediction. Project impacts considered insignificant.**	No

Killer whale – Eastern North Pacific Southern Resident, Eastern North Pacific Transient and Eastern North Pacific Offshore stock	**Southern Resident stock only Endangered.** Three of the five killer whale stocks recognized within the Pacific U.S. EEZ may occur in the Project area. Eastern North Pacific Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from British Columbia through California; Eastern North Pacific Transient stock - occurring from Alaska through California; Eastern North Pacific Offshore stock - occurring from Southeast Alaska through California. Off the coast of Oregon and California, 105 Transient whales and 56 Offshore whales have been identified (Carretta et al. 2011). Sightings of killer whales occur very infrequently in the Investigation area (Padre 2011, K. Winfield, Sub Sea Tours, 2011), but the Endangered Southern Resident stock of killer whale is considered not likely to be present within Central California waters. This stock is most commonly seen in the inland waters of Washington state and southern Vancouver Island; however, individuals from this stock have been observed in Monterey Bay, California, in January 2000 and March 2003, near the Farallon Islands in February 2005, and off Point Reyes in January 2006. The SERDP-SDSS summer stratum density estimate for all stocks of killer whales was 0.000709 km^2.	**Southern Resident stock: Chance of any Southern Resident stock killer whales appearing near the Project site is extremely remote. Likelihood of individual effects (including NMFS level A or B take) considered remote due to extremely low density prediction.** **Project is not likely to adversely affect Southern Resident stock killer whales.** **Eastern North Pacific Transient stock:** Potential Biological Removal=2.8. **Eastern North Pacific Offshore stock:** Potential Biological Removal=1.6 Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density (all stocks) estimate (Barlow et al. 2009). Wide-ranging populations with chance of sightings considered remote. **Project may affect, but is not likely to adversely affect Eastern North Pacific Transient and Eastern North Pacific Offshore stocks**	No

Pinnipedia			
California sea lion	The US stock best population estimate is 296,750. Seasonal abundance of California sea lions off central California is linked to spring and fall pre- and post-breeding migrations, with greater numbers of sea lions present during the Oceanic season, just after breeding (August –November, NCCOS 2007). Mainly males and sub-adults present during study period. Numbers inter-annually variable due to El Niño events, when numbers in central California may increase. Typically forage within 20 nmi of shore. Species with maximum number of sightings by Padre (2011). A NOAA aerial survey in September 2008 counted 2,385 animals at 7 locations between Point Sal and San Simeon, with 870 animals counted at Lion Rock, near Point Buchon. During summer counts small numbers (<20) of pups have been counted at sites within the Investigation area (M. Lowry, NOAA, 2011).	Potential Biological Removal=9,200. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Koski et al. 1998). Very abundant pinniped that uses Investigation area as migration route and for haul-out. **Quantification of project and acoustic impacts on population required.**	Yes
Northern elephant seal	Best population estimate is 124,000 for California breeding stock. Widely distributed offshore, shelf, shelf-break, and slope habitats. Adult males feed along the continental margin between coastal Oregon and the western Aleutian Islands. Adult females range across a wider area in the northeastern Pacific. Large rookery at Piedras Blancas (15,000+ population, B. Hatfield, USGS) north of the Investigation area. Rookeries are occupied year-round; abundance, age, class and sex of the seals at each site change throughout the year. Yearling/juvenile molt September-November and breeding in December-mid March, with peak pupping in late January. Central California at-sea data set reported by NCCOS 2007 (surveys 1980-2003) indicated infrequent single animals within the investigation area. A total 10 sightings were made within nine 10x10 km quadrats adjacent to the Investigation area. No sightings reported by Padre (2011). At-sea density estimated by Koski et al. (1998), August-November for Stratum 1 = 0.15593 km^2.	Potential Biological Removal=4,382. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and at-sea density (Koski et al. 1998). Very large PBR relative to local density. Forage largely offshore, less frequent inshore. Juveniles and yearlings likely at or near molt site to North. **Project may affect, but is not likely to adversely affect Northern elephant seals.**	No

Pacific harbor seal	California stock best estimate 30,196. Harbor seals are a widely distributed coastal species. Considered resident to area. Foraging is typically near shore (less than 5 miles) on fish and cephalopods. Pupping generally occurs March – June and molting generally occurs May – July. Haul-out counts were undertaken by NOAA in summer 2002, 2004 and 2006. A maximum estimate of 1,858 individuals for the area Point Sal to San Simeon was recorded in 2004 using aerial surveys (Mark Lowry, NOAA, 2011). Concentrations (~50-300) were recorded in the vicinity of Cayucos Point, Diablo Canyon, Estero Point, China Harbor, Morro Bay Estuary, Fossil Point, South Point, Point San Luis, and Point Buchon. Based on aerial surveys, total population likely >3,000 individuals (assuming an at-sea correction factor of 1.65, Lowry et al. 2008). At-sea density estimated by Koski et al. (1998), August-November for Stratum 1=0.02336 km^2.	Potential Biological Removal=1,600. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and density estimate (Koski et al. 1998). **Quantification of project and acoustic impacts on population required.**	Yes
Northern fur sea	Eastern Pacific stock population is 653,171 and San Miguel Island stock population is 9,968. The great majority of fur seals breed and pup off Alaska. Considered pelagic with a strong preference for offshore waters (Bonnell et al. 1992 cited in PG & E 2011). A small percentage of Northern fur seals (recognized as a separate stock) breed in the summer at San Miguel Island off Southern California and occur there year-round. A small rookery recently was re-established in 1996 at Southeast Farallon Island. Central California at-sea data set reported by NCCOS 2007 (surveys 1980-2003) indicated zero density estimates for Investigation area during the Oceanic season (August 15 – November 15). At-sea density estimated by Koski et al. (1998), August-November for Stratum 1=0.03095 km^2.	Potential Biological Removal=324 for San Miguel stock. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and at-sea density estimate (Koski et al. 1998). No haul-outs in Investigation area. Strong preference for pelagic habitat. Flexible foraging strategy and habitat use. **Project may affect, but is not likely to adversely affect northern fur seals.**	No

Guadalupe fur seal	**Threatened.** Mexico to California stock best population estimate 7,408. Guadalupe fur seals reside in the tropical waters of the Southern California/Mexico region (Carretta et al. 2011). During breeding season, they are found in coastal rocky habitats and caves. Little is known about their whereabouts during the non-breeding season (September to May), but some individuals travel north in late summer to the Channel Islands (NSF 2011) and may occur in small numbers in Central California but no sightings were recorded in the review by NCCOS (2007). Foraging is considered to be mainly pelagic.	**Likelihood of individual effects (NMFS level A or B take) considered remote due to extremely low density prediction.** **Project may affect, but is not likely to adversely affect Guadalupe fur seal.**	No
Northern (Steller) sea lion	**Threatened.** Eastern Stock best population estimates range between 58,334 to 72,223. The center of abundance of the Eastern Steller sea lion stock is BC and South East Alaska. The closest rookery to the Investigation area is Año Nuevo Island, in San Mateo County, Northern California, where 308 adults and juveniles were counted in 2009 and no critical habitat has been designated to the south (Allen and Angliss 2011). The two haul-outs in the Investigation area have mean July counts (averaged across 2002-2004) of 1-2 animals, with only 5 individual animal sightings south of San Simeon and north of Point Sal based on the Central California at-sea data set reported by NCCOS 2007 (surveys 1980-2003). No densities were calculated by Koski et al. (1998)	Potential Biological Removal for Eastern stock=2,378. **Likelihood of individual effects (NMFS level A or B take) considered remote due to very low density prediction.** Species is at the extreme end of their southerly range. Large population with large PBR. Chance of Steller sea lions being within Project area rare. **Project may affect, but is not likely to adversely affect Steller sea lions.**	No

Mustelidae			
Southern sea otter	**Threatened.** California stock best population estimate 2,862. Resident species with year-round occupancy. The southern sea otter inhabits the near shore waters of the central California coast and at present the range extends from about Half Moon Bay in the north to Santa Barbara in the south. Breeds June-July and October-November. Invertebrates form majority of diet. Although sea otters occasionally make dives of up to 100 m, the vast majority of feeding dives (~99%) occur in waters less than 40 m in depth (Tinker et al. 2006). Typically, dive depths of females <30m and males <40m. Spring 2010 USGS survey from San Simeon to Point Sal, there were 788 independent otters and 86 dependent pups for a total of 874 sea otters (T. Tinker, USGS, pers. comm., 2011). Minimum population estimate=2723. Highest density within Investigation area is in the Point Buchon area (USGS 2010).	Potential Biological Removal=8. Annual anthropogenic mortality=6.6 Investigation site overlaps major portion of range and contains ~30% of population. One of two annual breeding times occurs during survey. **Quantification of project and acoustic impacts on population required.**	Yes

[1] Data was collated from a variety of sources quoted within the text and also including NOAA stock assessment reports; Koski et al. 1998 Section 2; EIR section 4.4.4; and NCCOS (2007).

3.7 Justification for use of additional threshold for acoustic take assessment (dual threshold criteria)

3.7.1 Current status of marine mammal noise exposure threshold: Auditory and behavioral thresholds of Southall et al. (2007) and implications of subsequent data

Over the last decade, there has been an increasing amount of new science to assess the potential effects of noise on marine life, including marine mammals. Recently, an expert panel was convened to summarize the available data on marine mammal hearing and behavioral and physiological responses to sound and to propose new exposure thresholds (Southall et al. 2007). The proposed thresholds for the onset of these effects were segregated according to differing functional hearing capabilities of five groups of marine mammals (low, mid, and high-frequency cetaceans and pinnipeds in air and water) and different noise metrics (peak and rms sound pressure and SEL for both impulsive and non-impulsive types of sound).

The resulting review and interpretation of the available literature on injury and behavioral data, using precautionary extrapolation procedures, resulted in the derivation of frequency-weighting functions for each functional group, quantitative dual-metric exposure threshold s for auditory injury, and derivation of a "severity scale" for behavioral responses. There were clear and acknowledged data gaps in many areas, some of which are quite relevant to the consideration of noise impacts in the proposed CCCSIP Project, and Southall et al. (2007) clearly stated both the need for a precautionary application and the acknowledgement that application of new thresholds would not necessarily be uniform or simple in practice. Where the science suggests a more protective approach (e.g. particularly sensitive species, endangered species with few data), a more protective approach was believed warranted. Further, Southall et al. (2007) expected that this first broad assessment of noise exposure criteria for marine mammals would evolve and improve with the acquisition of subsequent scientific data. This has clearly been the case since the publication of the initial noise exposure criteria, resulting in some slightly different interpretations or modifications to the Southall et al. (2007) conclusions.

As predicted, additional data have become available that would clearly modify the conclusions reached by Southall et al. (2007). These include several important papers on auditory impacts, including TTS in harbor porpoise hearing (Lucke et al. 2009) and an expanded understanding of TTS in other odontocete cetaceans (e.g., Mooney et al. 2009a; 2009b; Finneran and Schlundt 2010; Finneran et al. 2010a; 2010b). A recent study (Kujawa and Liberman 2009) involving human subjects demonstrates the onset of PTS in hearing from repeated TTS. Despite recent assertions, however, this would not affect the conclusion reached in Southall et al. (2007) that 40-dB onset TTS is a reasonable proxy for injury onset (PTS) given that large TTS onset values were involved in the Kujawa and Liberman (2009) assessment. New data regarding the behavioral responses of marine mammals have also become available since the Southall et al. (2007) criteria. Among these are data related to the clear and sustained behavioral responses of beaked whales to simulated and actual military sonar (McCarthy et al. 2011; Tyack et al. 2011).

The Southall et al. (2007) noise exposure criteria, with some modifications based on more recent scientific data, are considered the current state-of-the-art standard in terms of marine mammal noise impacts. However, the more recent results must be considered and integrated as appropriate, in a current assessment of potential hearing and behavioral impacts. In the U.S., the NMFS has not undertaken a wholesale acceptance of the Southall et al. (2007) exposure criteria as a stated policy for all sound sources, although elements have been used in regulatory decision-making regarding military sonar (NOAA 2009a; 2009b). For impulse noise associated with seismic surveys, NMFS is currently using

estimated thresholds derived earlier and incorporated into current regulations. For the CCCSIP Project EIR, we assess the potential impacts according to these current regulatory thresholds, as well as relative to a derivation of those proposed by Southall et al. (2007) that take into account some of the more recent scientific data. The justification for this dual-threshold approach is described below.

3.7.2 Proposed dual-threshold approach for take assessment

3.7.2.1 Current NMFS thresholds

For the past several decades, NMFS has used single thresholds for the assessment of potential auditory and behavioral impacts from the noise associated with seismic surveys and continuous noise. These thresholds are based on early studies and assessments and do not include some of the considerations regarding acoustic metrics or differential auditory sensitivity to different frequencies among different mammal groups.

In terms of acoustic injury from any sound type, NMFS relies on the HESS (1999) panel assessment based on information available at that time (prior to most of the existing literature on marine mammal TTS). These thresholds are 180 dB re: 1 µPa (rms) for all cetaceans and 190 dB re: 1 µPa (rms) for all pinnipeds. For behavioral harassment from noise exposure, different thresholds are used for different sound types. A single threshold of 160 dB re: 1 µPa (rms) is used for impulsive noise, based on the results of Malme et al. (1983; 1984) and Richardson et al. (1986). A single threshold of 120 dB re: 1 µPa (rms) is used for continuous noise, based on the findings of Malme et al. (1984) and Richardson et al. (1990).

These thresholds are used in the current EIR assessment of potential auditory and behavioral impacts for comparison with the approach currently conducted and required by NMFS under the Marine Mammal Protection Act of 1972.

3.7.2.2 Southall et al. (2007) derived exposure thresholds

In addition to the standard NMFS thresholds for assessing potential effects of noise exposure, the Southall et al. (2007) exposure thresholds were used following a series of modifications described below that are intended to account for more recent data. We thus use firstly 'Injury SEL' thresholds (modified from SEL thresholds reported in Southall et al. 2007) as equivalent to NMFS Level A takes and secondly 'Probabilistic Disturbance rms' thresholds (a derivation based on the Southall et al. (2007) recommendations) as equivalent to NMFS Level B takes.

3.7.2.2.1 Acoustic injury thresholds (PTS-onset)

Southall et al. (2007) estimated PTS-onset as noise exposures estimated to result in 40dB of TTS for different sound types, using both a peak pressure and an SEL criterion; the SEL threshold is ultimately the functional criteria for most realistic exposure scenarios. For all cetacean functional hearing groups, estimated TTS onset levels for both impulse and non-impulse noise were based on data obtained in a few individuals of two mid-frequency species (bottlenose dolphins and belugas). For pinnipeds, some data were available on non-impulsive noise but extrapolations to PTS-onset for impulsive noise (such as that associated with seismic airguns) also included extrapolations involving data from bottlenose dolphins. The SEL threshold for PTS-onset to impulse noise for mid-frequency cetacean species (198 dB re: 1 μPa^2-s) and pinnipeds (186 dB re: 1 μPa^2-s) remain as valid (given the underlying assumptions) as when they were initially presented by Southall et al. (2007). However, subsequent data require some modification for other species groups.

For high-frequency cetaceans (e.g., harbor porpoises), subsequent data are available by Lucke et al. (2009). These data indicate lower TTS onset value both in terms of SEL and peak pressure. In this analysis, these directly relevant data form the basis for estimating TTS onset and potential for injury for harbor porpoise and other high-frequency cetaceans, rather than the extrapolated predictions of Southall et al. (2007). A PTS-onset threshold of 179 dB re: 1 μPa^2-s is used for this functional hearing group, based on Lucke et al. (2009) TTS-onset levels and the Southall et al. (2007) extrapolation procedure to PTS.

An additional consideration regards the assessment of potential auditory effects of impulse noise on low-frequency cetaceans (mysticetes). In the absence of direct measurements of hearing or noise impacts in any mysticete species, subsequent data on TTS in other cetaceans calls into question the hearing group extrapolation of results proposed by Southall et al. (2007). Specifically, Finneran and Schlundt (2010) recently demonstrated a greater sensitivity to non-impulse noise exposure for mid-frequency cetaceans at higher frequencies (within their region of best sensitivity) than had been tested when the Southall et al. (2007) criteria were published. Given the measurements of lower TTS onset values in the region of best hearing sensitivity for mid-frequency cetaceans, a more conservative extrapolation of results to low-frequency cetaceans, given the low frequency nature of seismic airgun impulses, was considered justified (see Southall et al. 2007). For reasons relating to the much higher natural ambient background levels at low frequencies and presumed adaptations in basic hearing capabilities of these species than for other cetacean species (see Wartzok and Ketten 1999), rather than a direct application of the high-frequency cetacean TTS-onset values, a more conservative extrapolation of the mid-frequency TTS onset data for impulse noise than proposed by Southall et al. (2007) was applied by subtracting 6 dB (which is halving the magnitude in terms of sound pressure) from the original Southall et al. (2007) level, for a resulting PTS-onset threshold for mysticetes of 192 dB re: 1 μPa^2-s.

3.7.2.2.2 Behavioral response thresholds

Southall et al. (2007) reviewed the available marine mammal literature and proposed a severity scaling for behavioral response applied to the available data, but did not present explicit step-function thresholds for behavioral response. This was because of the lack of convergence in the data on broadly-applicable exposure levels resulting in significant behavioral responses. The Southall et al. (2007) review found that contextual factors of sound exposure relating to different animal groups, sound types, exposure conditions, and differing activity states complicate efforts to derive simple step-function thresholds for all species. The approach proposed was to make efforts to account for both species and contextual differences. That approach has been adapted for this analysis.

For the majority of marine mammal species, a method similar to the NMFS step-function threshold (160 dB re: 1 µPa (rms)) for impulse noise is used. As reviewed in detail in Appendix II ("Studies Involving Marine Mammal Behavioral Responses to Multiple Pulses") of Southall et al. (2007), most marine mammals exposed to impulse noise demonstrate responses of varying magnitude in the 140-180 dB re: 1 µPa (rms) exposure range, including the mysticetes in the Malme et al. (1983; 1984) studies on which the NMFS threshold is based. Potential disturbance levels at SPL above 140 dB re: 1 µPa (rms) were also highlighted in HESS (1999). For the current assessment, a probabilistic metric is applied at which 10%, 50%, and 90% of individuals exposed are assumed to produce a behavioral response at exposures of

140, 160, and 180 dB re: 1 µPa (rms), respectively. One final difference is that frequency weighting curves (the M-weighting of Southall et al. (2007)) is applied to these exposure estimates.

As noted by Southall et al. (2007) and supported by subsequent data, certain marine mammal species and certain marine mammals in specific behavioral modes, appear to be significantly more sensitive to noise exposure. For instance, migrating Bowhead whales are much more likely than other mysticetes (including feeding bowhead whales) to respond clearly to seismic airgun noise at much lower (~120-140 dB re: 1 µPa (rms)) received sound levels (Richardson et al. 1999). As a protective approach for this behavioral state – 10%, 50%, and 90% response probability for migrating mysticetes is estimated to occur at M-weighted exposure levels of 120, 140, and 160 dB re: 1 µPa (rms).

Finally, certain species including harbor porpoises and beaked whales appear to have a categorically-different level of response than other marine mammals to much lower received levels. As reviewed in Southall et al. (2007), for harbor porpoises this appears to be consistent across sound types and laboratory and field settings. As recently demonstrated by Tyack et al. (2011), beaked whales appear to share this particular sensitivity, which may in part explain their disproportionate representation in marine mammal stranding events associated with sound exposure. Based on the initial assessment of Southall et al. (2007) and considering the more recent supporting evidence for beaked whales specifically, a particularly sensitive behavioral response category for these species and porpoises is assessed here. NMFS also recognizes species and contextual factors in setting behavioral response thresholds, the most obvious being the use of a 120 dB re: 1 µPa threshold for behavioral response of harbor porpoise to Navy acoustic sources with a wide range of activities (U.S. DON 2008). Thus, for these species groups, independent of behavioral state, 50%, and 90% behavioral response probabilities are calculated for M-weighted exposure levels of 120, and 140 dB re: 1 µPa (rms). The 10% probability was not modeled in this case, but the 50% criterion is used as a step function.

Table 3.8 provides a summary of the Injury SEL thresholds used for the proposed Project to estimate Level A takes, and compares these thresholds with those published in Southall et al. (2007). Only low frequency and high frequency cetacean thresholds change. Table 3.9 provides a synopsis of the thresholds and the probability of a Level B behavioral response. Probabilities are not additive and reflect single points on a theoretical response curve.

Table 3.8 Modified Injury Sound Exposure Level (SEL) thresholds for multiple pulses used in this analysis and those originally proposed by Southall et al. (2007) to estimate onset of acoustic injury (Level A - PTS).

Marine Mammal Group	**Injury SEL thresholds used in this analysis (dB re: 1 µPa^2-s)**	**Southall et al. (2007) – published SEL (dB re: 1 µPa^2-s)**
Low frequency cetacean	192	198
Mid frequency cetacean	198	198
High frequency cetacean	179	198
Pinniped (in water)	186	186

Table 3.9. Probabilistic Disturbance rms sound pressure level thresholds (M-weighted) used in the current analysis to predict a Level B behavioral response. For comparison, the NMFS threshold for behavioral response for all marine mammals is 160 dB re: 1 µPa (rms, un-weighted). Probabilities are not additive and reflect single points on a theoretical response curve.

	Probabilistic Disturbance rms thresholds M-weighted dB re: 1 µPa (rms)			
Marine Mammal Group	**120**	**140**	**160**	**180**
Porpoises/beaked whales	50%	90%		
Migrating mysticete whales	10%	50%	90%	
All other species/behaviors		10%	50%	90%

3.8 Marine mammal density estimate verification and validation

SERDP-SDSS models of cetacean densities in the Investigation area are based on SWFSC ship line-transect data collected from 1986 to 2006 and include over 17,000 sightings of cetacean groups on over 400,000 km of transect line, but coverage of the Investigation area is below average (see Barlow et al. 2009), partly due to sighting conditions such as fog (K. Forney NOAA, pers. comm. 2011). The output from an ecological model is an approximation to the truth with two components: a point estimate (such as the predicted number of whales resulting from a GAM) and an estimate of uncertainty associated with the point estimate. There are numerous sources of uncertainty in the cetacean-habitat population density models used. Barlow et al. (2009) state 'In our analyses, the greatest source of uncertainty is inter-annual variability in actual population density due to movement of animals within or outside of the study areas'. Across all years, density ratios (density calculated using standard line-transect methods divided by density predicted by the habitat model, Barlow et al. (2009)) were close to unity for most species (range 0.86 - 1.50), indicating that - on average - model density estimates were similar to line-transect density estimates. However, individual annual density ratios were more variable ranging from approximately 0.3 to 3.0, indicating that predictions for any given year were within a factor of three of the standard line-transect density estimates.

The SERDP-SDSS model is optimized for large scale density predictions using broad habitat variables and consequently is not optimal for accurate predictions at the scale of this study. Density estimates were therefore verified independently by two senior scientists who have undertaken more than two decades of surveys and abundance estimates in the region (K. Forney NOAA, 2011; J. Calambokidis, Cascadia, mysticete only, 2011). Following review, both scientists independently considered the mean density for humpback whales to be low (by a factor of 2 or 3) and considered that the upper confidence interval SERDP-SDSS Model density estimate for humpbacks does not reflect potentially high density 'hotspot' years that have been observed in previous years by smaller scale surveys not included in the model (see section 3.8.1). Similarly, high densities of blue whales have been occasionally encountered in early fall in the area (J. Calambokidis, Cascadia, Pers. Comm. 2011, see section 3.8.1).

Validations undertaken by Barlow et al. (2009) for central California (east sector) across 5 survey years confirmed line transect estimates were on average 2.3 times higher than model predictions for humpback whales. At a large scale abundance and subsequent density estimates take account of area movements by animals, but on smaller geographical scales the model does not reflect turnover of animals. In addition to incorporating baseline density estimates into acoustic take models, upper

confidence density estimates were used as well as a 'potential' density that reflected SERDP-SDSS Model underestimates for Fin and humpback whales and applied a conservative level of turnover to reflect 'Potential' non-static densities. In addition, aerial survey estimates for minke whales were not corrected for animals that were on the track line but missed because they were diving and therefore they are considered an underestimate. An analysis of NOAA unpublished data provided a considerably higher density estimate for minke whale (K. Forney NOAA, Pers. Comm., 2011), and though these are not incorporated into the present population estimate nor PBR estimates, they were considered in the adverse effects assessment of this report.

3.8.1 Inter-annual variability in mysticete

Euphausiids (krill) form a key trophic link in coastal upwelling systems between primary production and higher trophic level consumers. The California Current Ecosystem is a highly productive ecosystem driven by seasonal wind driven upwelling. However the timing, duration and intensity of this upwelling varies significantly inter-annually and consequently affects euphausiid abundance (Benson et al. 2002). Bailey et al. (2010) highlight that changes in the location and duration of foraging activity are driven by this variation and blue whales modify their foraging response accordingly. For example, the El-Nino event of 1997-1998 led to high concentrations of baleen whales observed in Monterrey Bay (Benson et al. 2002) and increasing numbers of blue whales in Washington state waters and off Vancouver Island. A delayed upwelling in 2005 also led to blue whales moving further north due to a lack of prey. Humpback whales switch between krill and forage fish, but also show large inter-annual variations in density and location (Peterson et al. 2006; Calambokidis et al. 2008). Overall, for both species, the Investigation area is considered a transit/migration route, often for a substantial portion of the population, especially in fall when both species migrate south. Locally high abundances can occur within the Investigation area if and when suitable foraging conditions occur (NCCOS 2007). Suitable conditions vary between species, as humpbacks are able to take advantage of inshore fall (September/October) concentrations of anchovy/sardines. Mean time within a foraging patch was calculated for 159 satellite-tagged blue whales as averaging 21 days (Bailey et al. 2010) and is considered a representative temporal scale for other foraging mysticetes.

Cascadia Research Collaborative (e.g., Calambokidis et al. 2008) have undertaken and collated boat-based Photo-ID studies of humpback whales and blue whales off the US west coast since 1986. Effort has focused on a number of key areas (including the Santa Barbara Channel and Monterey Bay) with sporadic effort (often limited to 1-2 days of survey efforts in summer and/or fall) in the Investigation area off the Central California Coast. Expert opinion predictions for blue whales and humpback whales within 50 km of the Investigation area for early fall resulted in potential estimates of 100+ blue whales and 200-300 humpback whale individuals (J. Calambokidis, Cascadia, Pers. Comm., 2011), based on experience from these long-term surveys. Concentrations of this scale do not however occur regularly, but reflect temporal variation in foraging opportunities.

For example, in 2008, 3 days of local area effort (Point Conception to Point Sur) in mid-August yielded 100 sightings (87 unique IDs) of humpback whales. As well as 2008, humpbacks had high relative regional resight numbers in 2005 (168), 2004 (72), 2002 (44), 2000 (138), 1991 (195) and 1988 (117), in some years mostly between Point Conception to Point Buchon (1988, 1991, 2000, 2002) and other years between Point Buchon and Point Sur (2005, 2008) (Calambokidis et al. 2009). Table 3.10 provides summary information of humpback whale sighting in the locale of the Investigation area made by

Calambokidis et al. (2002; 2003). Data is also available from 1988-2007 NOAA harbor porpoise surveys (K. Forney, NOAA, Pers. comm., 2011) which noted concentrations of humpback whales

Blue whales are typically found concentrated in the Santa Barbara channel region to the south, (<100 km away) mainly between June and October, as well as the Farallones in September and October (Calambokidis et al. 2009). However, large numbers of blue whale were encountered during local based surveys in 2003 (42), 2002 (48), 2001 (21) and 2000 (37), and most of these sightings (88%) were found between Point Conception and Point Buchon (Calambokidis et al. 2009). Table 3.10 provides summary information of blue whale sighting in the locale of the Investigation area made by Calambokidis et al. (2002a; 2003; 2004). Data is also available from 1988-2007 NOAA harbor porpoise surveys (K. Forney, NOAA, Pers. comm., 2011) which also noted concentrations of blue whales.

Table 3.10 Summary of notable humpback and blue whale sightings during local vessel sighting surveys by Calambokidis et al. (2002a; 2003; 2004) and during NOAA porpoise surveys (1998-2007).

Species	**Number**	**Location**	**Date**	**Source**
Humpback whale	4	Survey around San Luis	4 November 2001	Calambokidis et al. 2002a
Humpback whale	36	Survey around San Luis	4 October 2002	Calambokidis et al. 2003
Humpback whale	12	Survey around San Luis	5 October 2002	Calambokidis et al. 2003
Humpback whale	8	Survey around San Luis	29 October 2002	Calambokidis et al. 2003
Humpback whale	25-35	N35°23.86’ W120°56.41’, Morro Bay Area	August 27 1991	K. Forney, SWFSC NOAA
Humpback whale	20-40	N35°01.31’ W120°46.59’, Pismo Beach area	1 November 1991	K. Forney, SWFSC NOAA
Humpback whale	12	N34°34.55’ W120°44.07’, South of Point Sal	7 October 2002	K. Forney, SWFSC NOAA
Humpback whale	Multiple	N34°52.51’ W120°45.44’, off Avila Beach	18 September 2006	K. Forney, SWFSC NOAA
Blue whale	0	Survey around San Luis	9 November 2001	Calambokidis et al. 2002a
Blue whale	23	Survey around San Luis	4 October 2003	Calambokidis et al. 2003
Blue whale	20	Survey around San Luis	5 October 2003	Calambokidis et al. 2003
Blue whale	2	Survey around San Luis	29 October 2003	Calambokidis et al. 2003
Blue whale	36	Survey around San Luis	August 31 2003	Calambokidis et al. 2004
Blue whale	25	N34°34.55’ W120°44.07’, South of Point Sal	7 October 2002	K. Forney, SWFSC NOAA

Less local area information is available for fin whales due to their deeper water habitat preferences. Overall, however, local fall survey information highlight that densities of both humpback and blue whales can in some years exceed Upper confidence level densities predicted by the SERDP-SDSS model, which amount to no more than 15 animals within the total area predicted to be ensonified to received levels of 160 dB re: 1 µPa (rms).

3.8.2 Depth dependent density assumptions

The SERDP-SDSS model incorporates depth as a potential variable (Barlow et al. 2009), but following additional scientific consultation (K. Forney NOAA, 2011; J. Calambokidis, Cascadia, 2011; Koski et al 1998), depth cut-offs were applied to five species, below which density was assumed to be zero (blue whales [<80m], beaked whales, Dall's porpoise, Northern right whale dolphin and sperm whale [<100m]. A maximum depth cut-off of 200m was applied to harbor porpoise (based on survey sighting data by Carretta et al. 2009). Coastal bottlenose dolphins were modeled only within the 1 km strip from shore.

3.9 Acoustic take methodology

Acoustic takes were calculated using two (dual) different sets of thresholds as summarized in Table 3.2 and described in Section 3.7 (NMFS rms Level A and B thresholds and Injury SEL Level A and Probabilistic Disturbance rms Level B thresholds). The NMFS and Southall methodologies used to estimate take are generally distinguished from each other as follows:

- NMFS take estimates: NMFS Level A and B thresholds are used to estimate ensonified areas representing the two types of effects. The NMFS thresholds do not account for differences in hearing sensitivity among cetacean species. Take is based on the area within the respective contours defined by the 95 percentile thresholds radii (i.e., outliers removed), and using three scenarios of estimated animal density (see Section 3.9.4). Contours were based on the maximum 95% radii from any active sound source using nine representative depth and bottom type location. Level A takes were modified to incorporate species-specific depth dependency, an estimate of expected avoidance reaction and the proposed use of MMOs and PAM to monitor the exclusion zone (Table 3.11). Level B takes were increased accordingly and also incorporated species-specific depth dependency.
  The proposed seismic lines run parallel to each other in close proximity (200-400 m); thus, there are areas were radii overlap (often multiple times), therefore, theoretically an individual may be exposed numerous times during the survey. Two take estimate approaches were calculated using NMFS threshold criteria: Using the 'Minimum' area ensonified (which excludes all areas of overlap and thus represents the absolute minimum number of individual takes based on the proposed Project footprint and a static density distribution, assuming no net immigration or emigration, *sensu* LGL 2009); Using the 'Maximum' area ensonified (which includes all overlap areas and includes repeated takes of the same individual). The NMFS 'Maximum' estimate is thus a cumulative total of the maximum area ensonified that incorporates the length of all the survey tracklines. The NMFS Maximum take estimate includes a contingency of 25% which was added to account for production lines that have to be reshot for various reasons (sensu LGL 2009), as well as the sound source verification period. The ratio of Maximum to Minimum take represents the 'intensity' of the entire survey within the Project footprint or the number of repeated times the Project footprint is ensonified. Repeated ensonification within the Project footprint can increase the number of individuals taken if net immigration occurs due to, for example, seasonal migration patterns. NMFS Maximum estimates apply an average density

throughout the survey period. Given reductions in mysticete density are likely to occur in November, then NMFS Maximum estimates will be overestimated to some extent.

- New take estimate based on Southall et al (2007): Level A thresholds (termed Injury SEL) are taken from Southall et al. (2007), but threshold values were reduced for Low and High frequency cetacean groupings (Table 3.8). In contrast to NMFS metrics, a cumulative 24 hour sound exposure level (SEL) was used that incorporated group-specific hearing sensitivities (termed M-weightings). Jasco Applied Sciences used a representative 24 hour period of track lines (~200 km) for each survey box to model the 24 hour cumulative M-weighted SEL due to all sound sources. The distance from the representative track line to the edge of the M-weighted area ensonified was then measured for turns as well as deep (>150m) and shallow (<150m) production areas to be used as buffer radii. Track lines for each survey box were then split into continuous segments that could be completed in 24 hours (~200km) and buffered by their appropriate radii. Overlaps in buffers within a day were dissolved, but not between days. Thus the area ensonified to a 24 hour cumulative SEL isopleth could be calculated and used to estimate a cumulative SEL take representative of the entire survey (plus an additional 25% reshoot contingency). Takes were modified to incorporate species-specific depth dependency, an estimate of expected avoidance reaction and the proposed use of MMOs and PAM (Level A) to monitor the exclusion zone (Table 3.11).

  Level B thresholds (termed Probabilistic Disturbance rms), like NMFS thresholds used rms metrics, but in addition included the use of group-specific M-weightings. A range of thresholds were selected ranging between 120- 180 dB re: 1 µPa (rms), with the probability of response (10%, 50%, or 90%, see Table 3.9) varying by species groupings and context (migrating versus non-migrating mysticete). Take is based on the area within the respective contours defined typically by the 95 percentile thresholds, and three scenarios of estimated animal density. Accurate estimates of transmission to the 120 dB re: 1 µPa (rms) isopleths are problematic and exhibit strong directionality (propagated greater distances downslope). Representative contour shape-files were therefore used to optimize the estimated area of ensonification. Level B takes incorporated species-specific depth dependency. Probabilistic Disturbance rms is comparable to NMFS Minimum in that it represents the Project's noise footprint and excludes areas of overlap.

In summary, a number of different parameters are required to calculate an acoustic take. These are the radii ensonified (RAD) by the airgun(s) to a predetermined noise threshold (see Section 3.6), the length of the survey track (T), the density of marine mammals (D) and weighting factors that take into account the APMs (APM: Level A only) and any assumptions on behavioral avoidance response (BAR: Level A only).

For rms based takes, calculation estimates were based generally on the following method

$$\text{Take} = RAD_{das} \times T_{da} \times D_{dvs} \times (BAR_s) \times APM_s$$

d = depth dependency component
a = airgun array or single airgun (or echosounder or sub-bottom profiler)
v = marine mammal density variability scenarios
s = species specific

3.9.1 Depth and substrate dependent radii

Acoustic isopleth radii from Jasco Applied Sciences were available for four (# 1,2,3,4 and 8) depth strata (<50 50-90m, 90-150m, 150-300m, >300m) for production lines and three (# 5, 6, 7 and 9) depth strata (< 50 50-150m, 150-300m, >300m) for the turns (Figures 3.2 and 3.3). Sites 8 and 9 were modeled on hard bottom substrate and are relevant to the proposed Project and Alternative 1 tracklines only. Two depth strata representing shallow and deep water were typically available for cumulative SEL based take estimates (See Appendix I). ArcGIS 10.0 was used to partition the study area into appropriate depth strata. Other assumptions include 1) Radii are representative across all water depths within that depth stratum, 2) diving by marine mammals does not impact received levels.

3.9.2 Production tracklines and the inclusion of echosounder and sub-bottom profiler

The length of the turns and production lines were calculated separately for the proposed Project and each Alternative. Based on information in PG&E Letter DCL-2011-646, thresholds for 3km of run-out and the last 3km of run in were buffered using the radii of the full airgun array. A Kongsberg EM 122 multibeam echosounder (MBES) and a Knudsen 320B sub-bottom profiler (SBP) will be used continuously during the CCSIP Project to better characterize the local bathymetry and sedimentary features. The MBES ensonifies a broad swath (150º beam pattern) of the bottom perpendicular to the movement of the vessel, but a very narrow swath (2º beam pattern) in the direction of travel of the vessel. The wide beam pattern is achieved by aiming multiple pulses at successive angles. The SBP ensonifies a cone 30° wide. The maximum source levels for the MBES and SBP are 242 dB re: 1 µPa (rms) and 204 dB re: 1 µPa (rms) respectively at dominant frequencies of 12 (MBES) and 3.5 kHz (SBP). Pulse duration for the units can vary from 2-15 ms for the MBES and 1-4 ms for the SBP. Therefore, in addition to array and single mitigation airgun sound sources, Jasco Applied Sciences modeled the propagation of sound from the MBES echosounder and sub-bottom profiler (Appendix I).

Predicted MBES or SBP radii for Level B rms threshold criteria clearly exceeded those of the single airgun at certain threshold levels. For rms-based estimates, Project tracklines were buffered by depth-specific array airgun, mitigation airgun, echosounder or sub-bottom profiler threshold radii (which ever was largest). This provided a combined active source take estimate. Cumulative SEL estimates for the proposed project and Alternative 1 included the contribution from the echosounder and sub-bottom-profiler, whereas they were not included in cumulative SEL estimates for Alternative 2. The impact of including the echo-sounder and sub-bottom profiler was assessed using data from Box 1 of the proposed Project. Cumulative 24 hour SEL estimates using data for airguns only represented 99.7% of the area for Low Frequency cetaceans, 91.4% for Mid Frequency cetaceans, 84.3% for High Frequency cetaceans and 97.7% for Pinnipeds. Cumulative SEL Modeling results for one day are depicted for the four proposed Project boxes 1,2,3,4 (Figures 3.4, 3.5, 3.6 and 3.7), as well as for Alternative 2 Zone 1 (Figure 3.8) and Zone 2 (Figure 3.9). Combined active acoustic source Level B area footprints were determined for the Project for both Probabilistic Disturbance rms and NMFS (Figure 3.10) thresholds, as well as all Alternatives. For further explanation of acoustic modeling for active sounds sources see Appendix I.

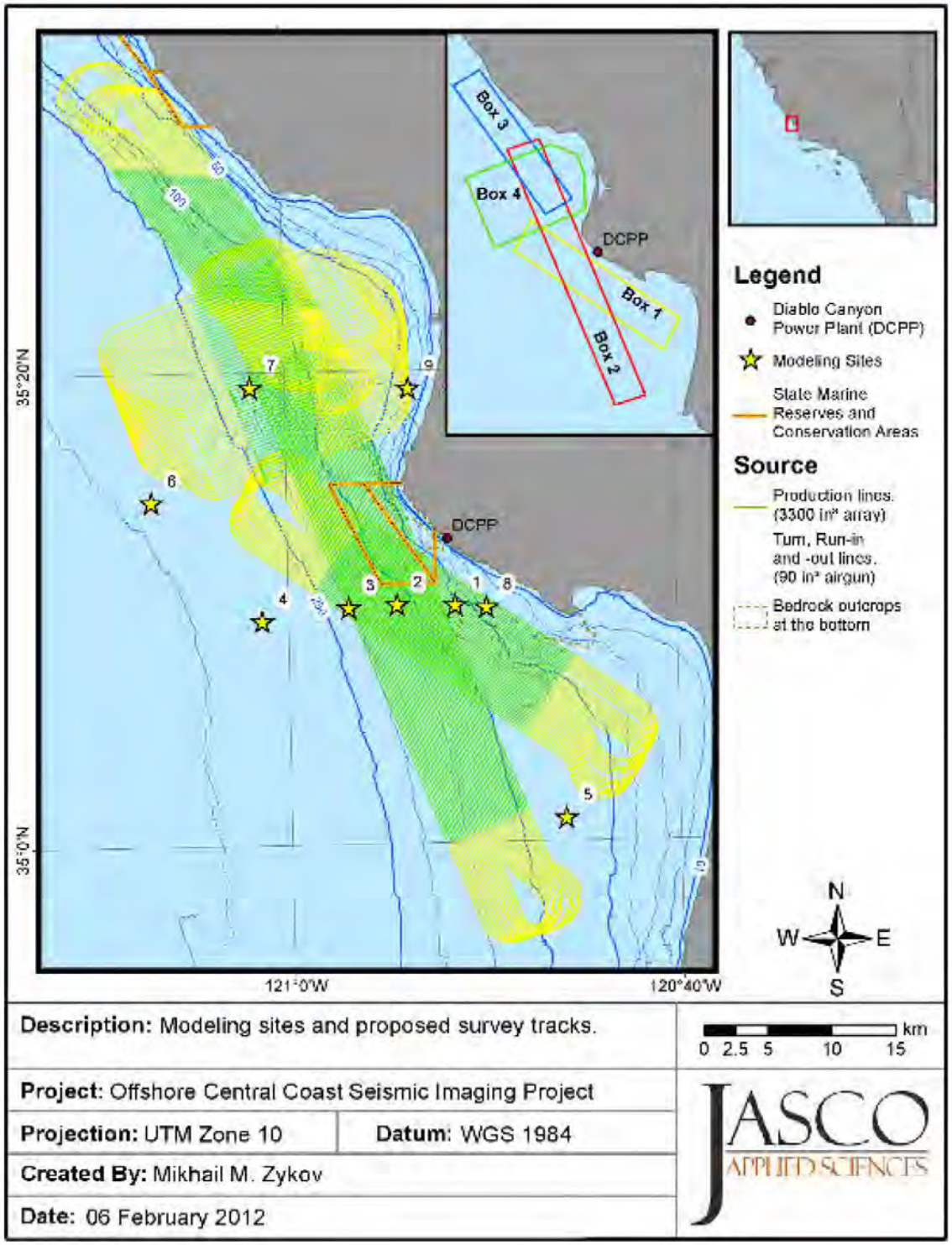


Figure 3.2 Application of the individual sites modeling results to the seismic tracklines relevant to the proposed Project and Alternative 1.

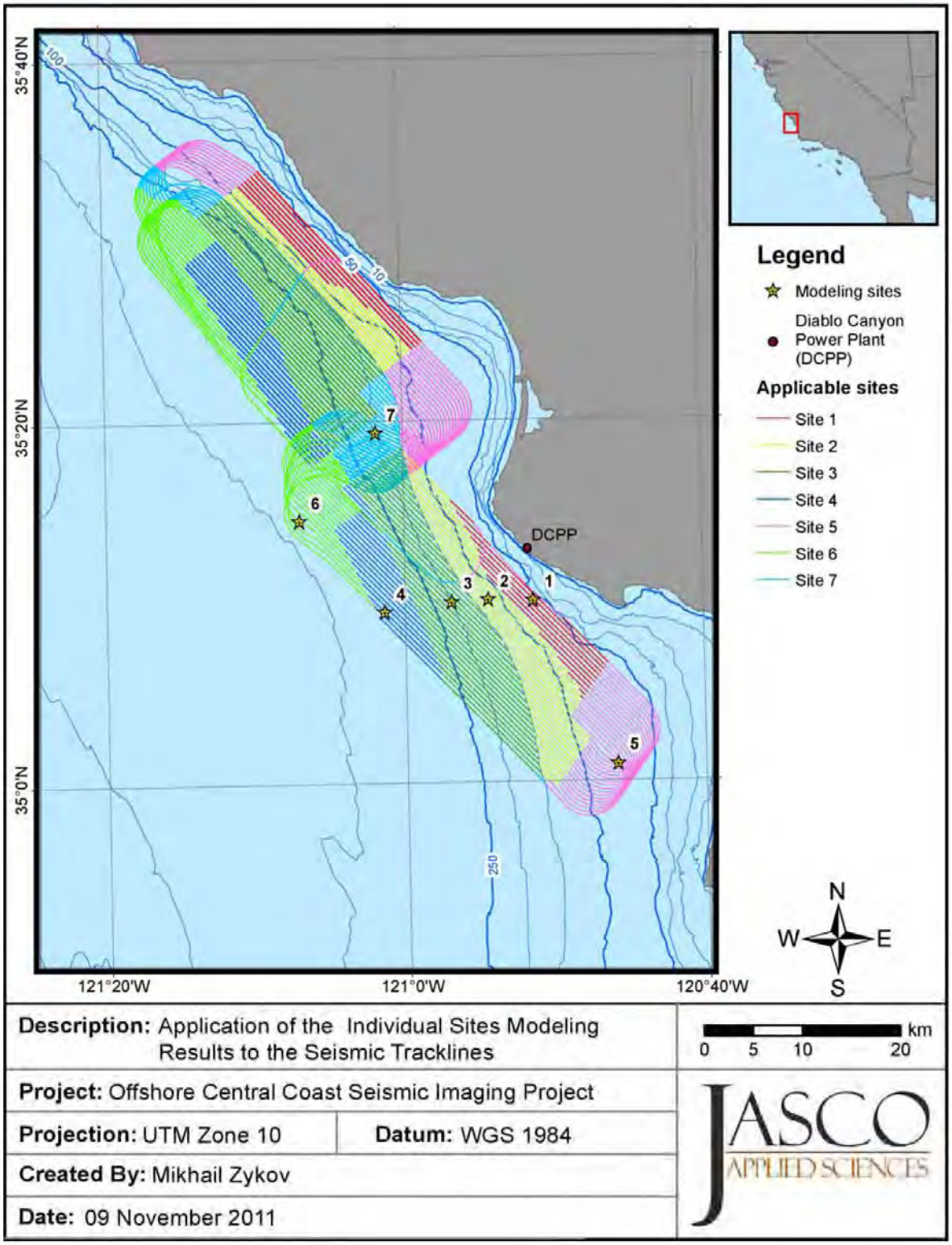


Figure 3.3 Application of the individual sites modeling results to the seismic tracklines relevant to Alternative 2.

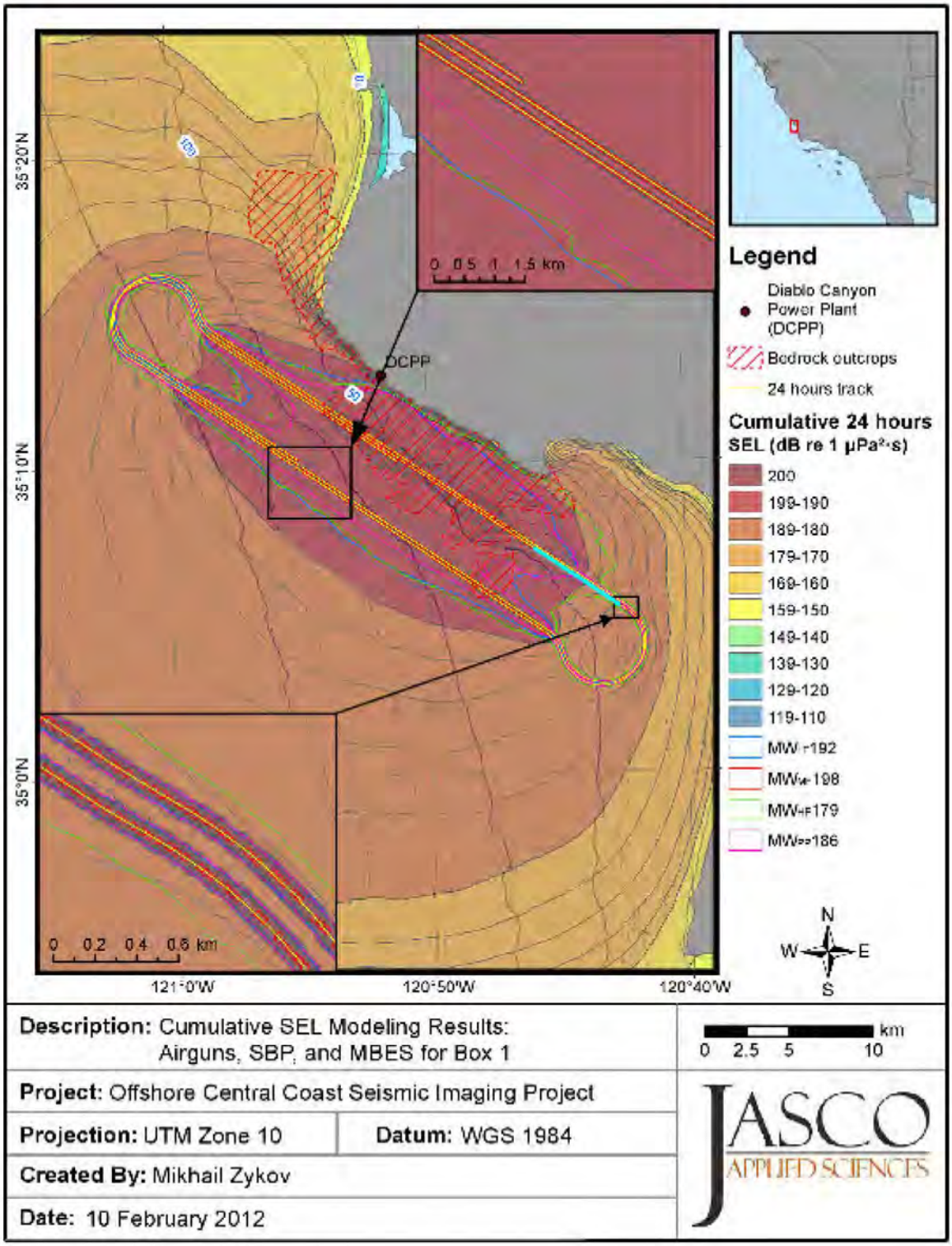


Figure 3.4 Cumulative SEL modeling results for Box 1 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB MW_{LF}, 198 dB MW_{MF}, 179 dB MW_{HF}, and 186 dB MW_{PP}.

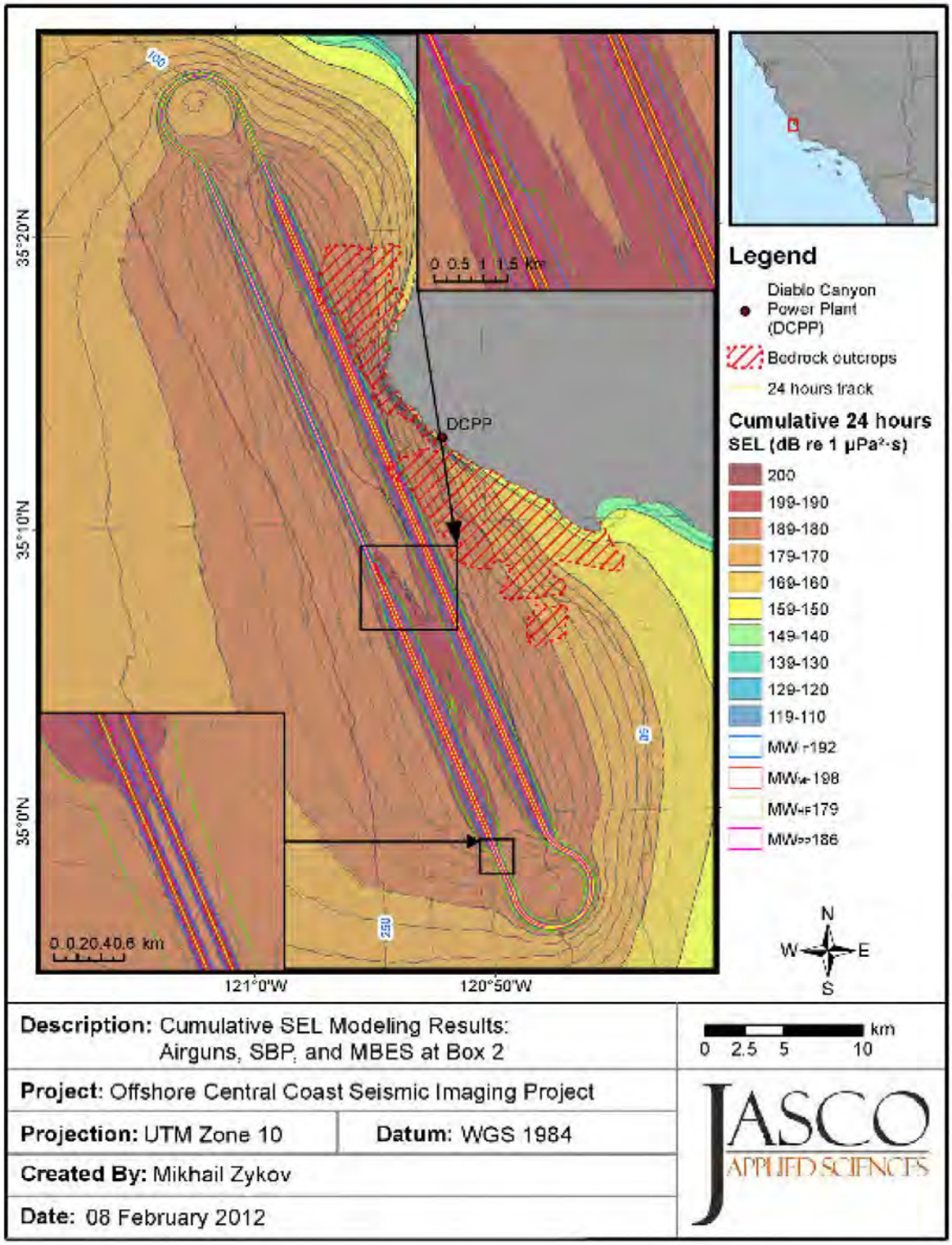


Figure 3.5 Cumulative SEL modeling results for Box 2 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB MW_{LF}, 198 dB MW_{MF}, 179 dB MW_{HF}, and 186 dB MW_{PP}.

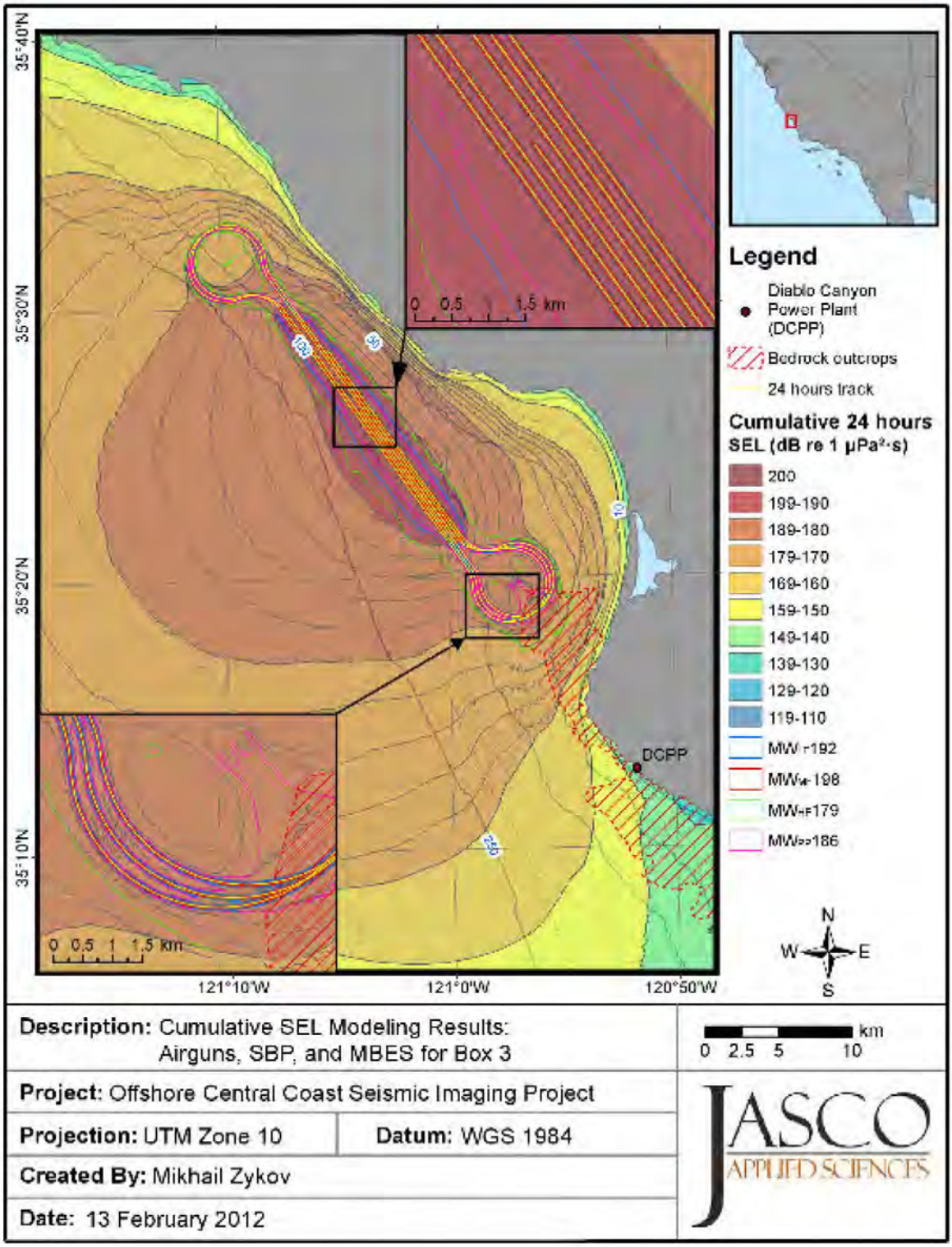


Figure 3.6 Cumulative SEL modeling results for Box 3 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB MW_{LF}, 198 dB MW_{MF}, 179 dB MW_{HF}, and 186 dB MW_{PP}.

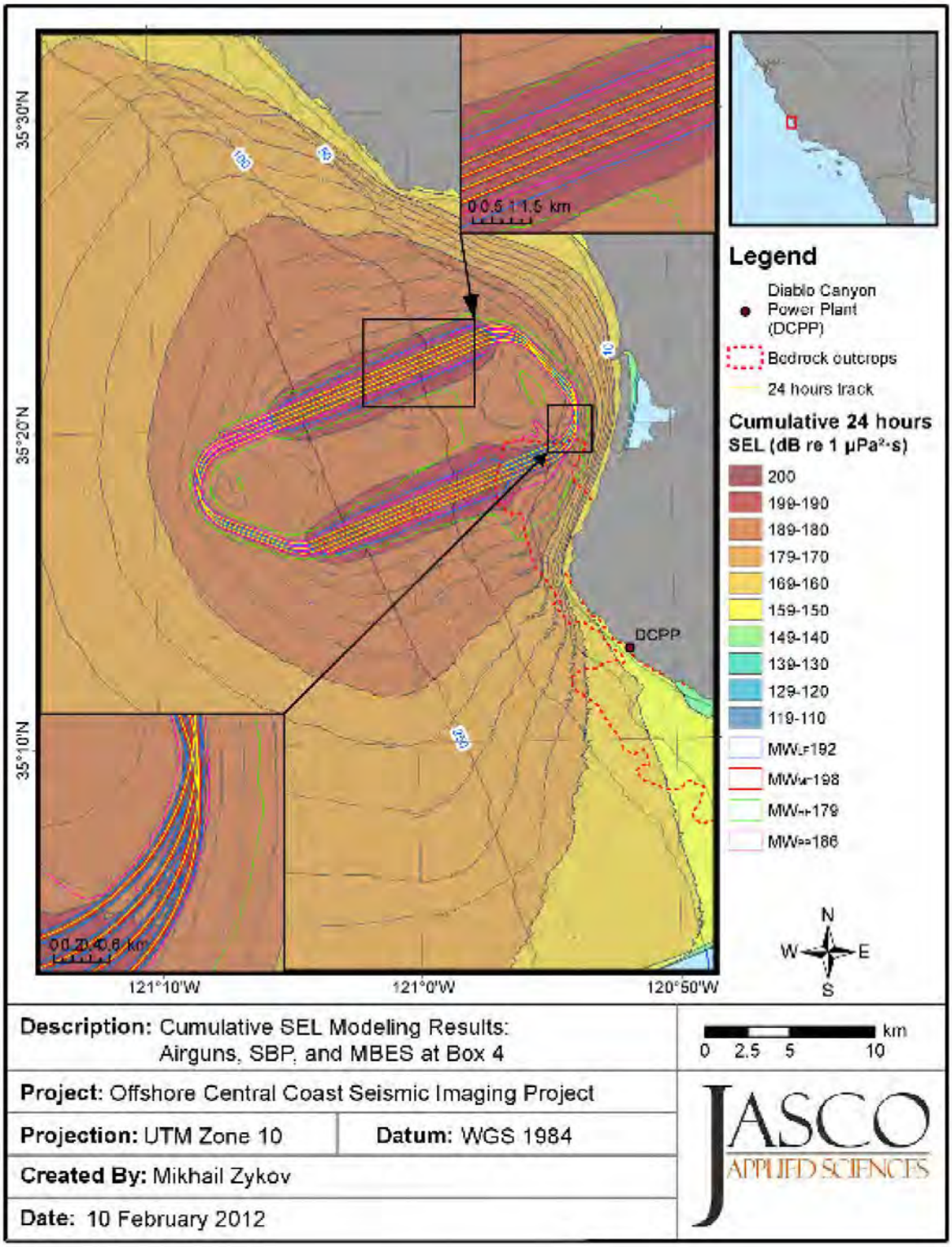


Figure 3.7 Cumulative SEL modeling results for Box 4 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB MW_{LF}, 198 dB MW_{MF}, 179 dB MW_{HF}, and 186 dB MW_{PP}.

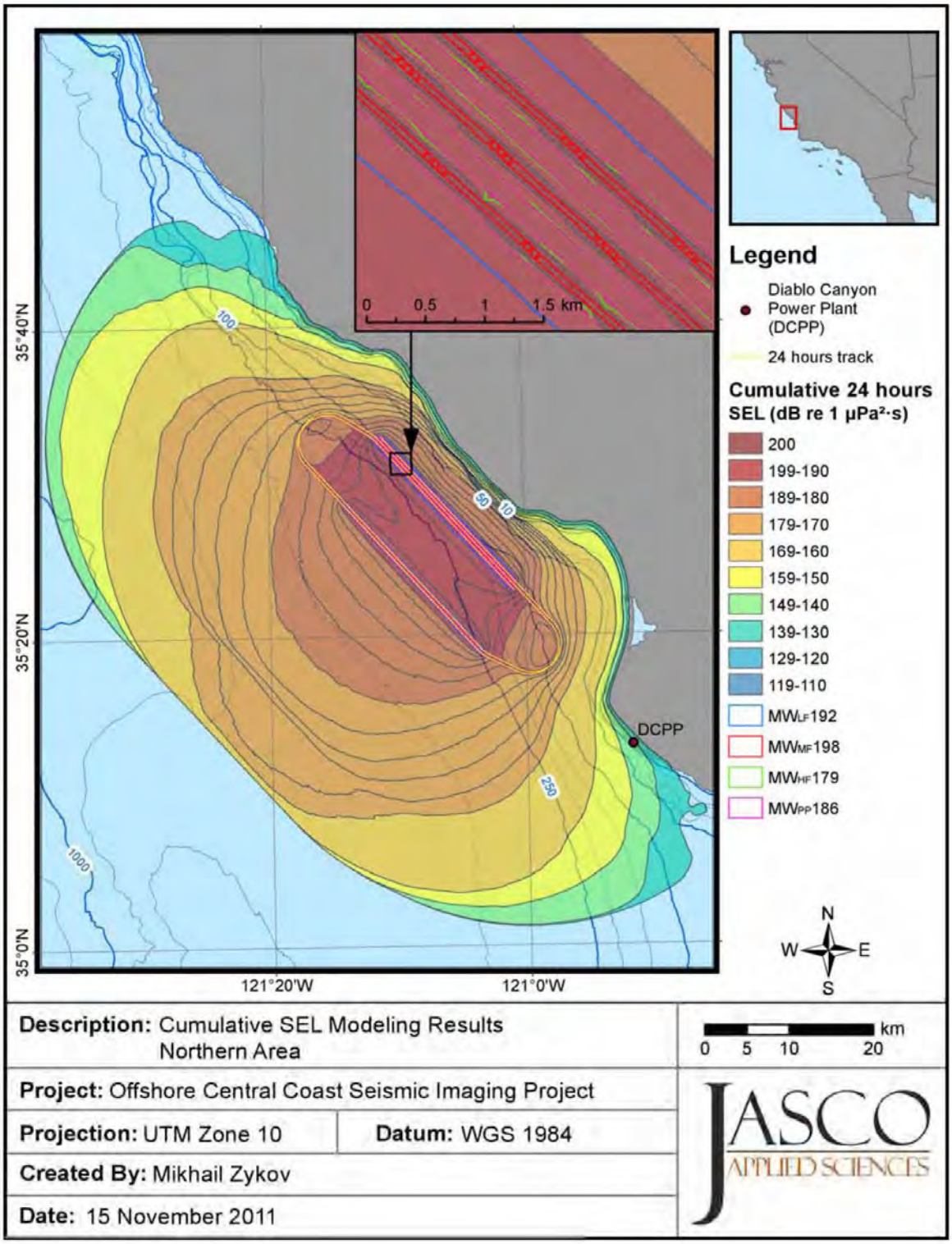


Figure 3.8 Cumulative SEL modeling results for Zone 1 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB MW_{LF}, 198 dB MW_{MF}, 179 dB MW_{HF}, and 186 dB MW_{PP}.

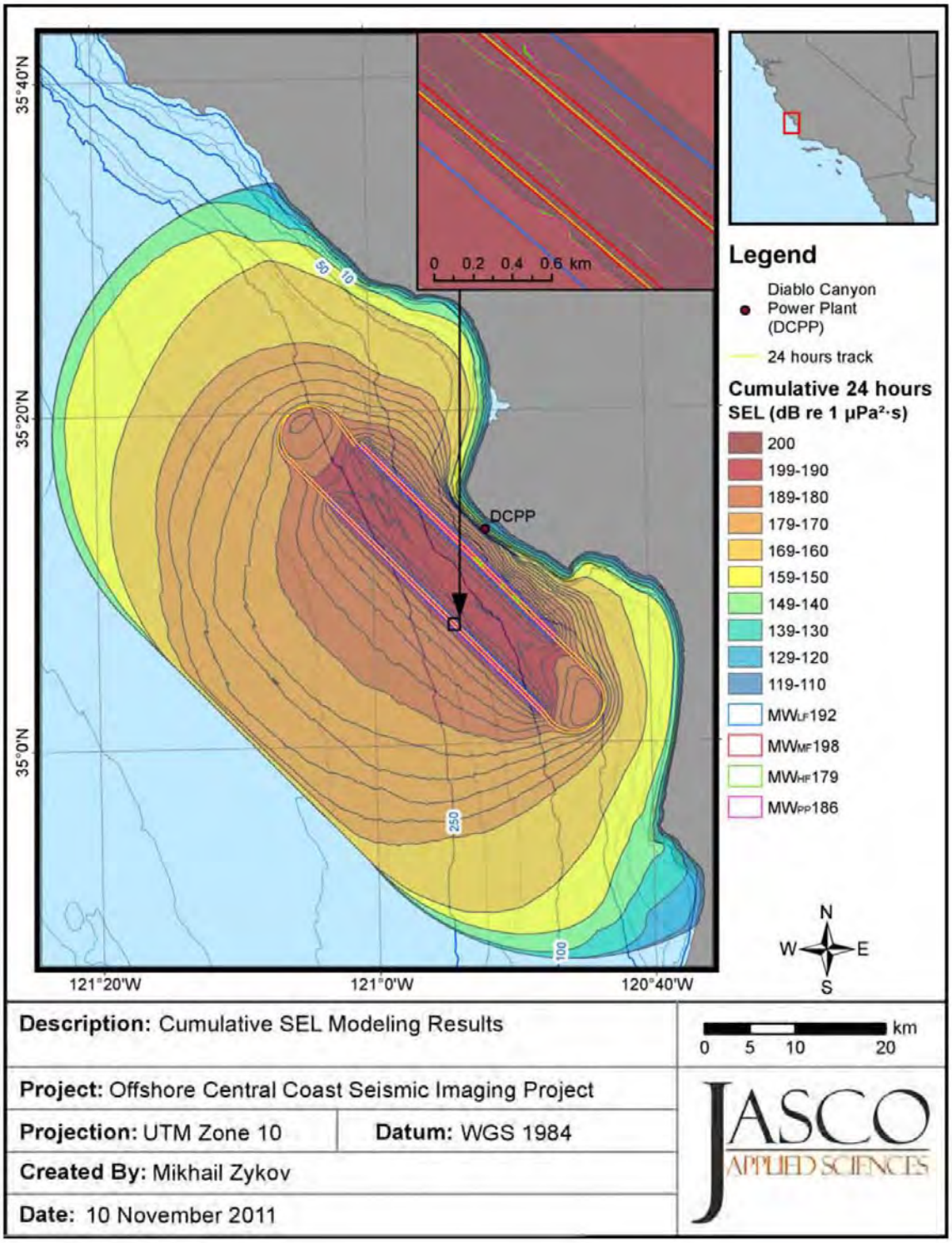


Figure 3.9 Cumulative SEL modeling results for Zone 2 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB $MW_{LF,}$ 198 dB $MW_{MF,}$ 179 dB MW_{HF}, and 186 dB MW_{PP}.

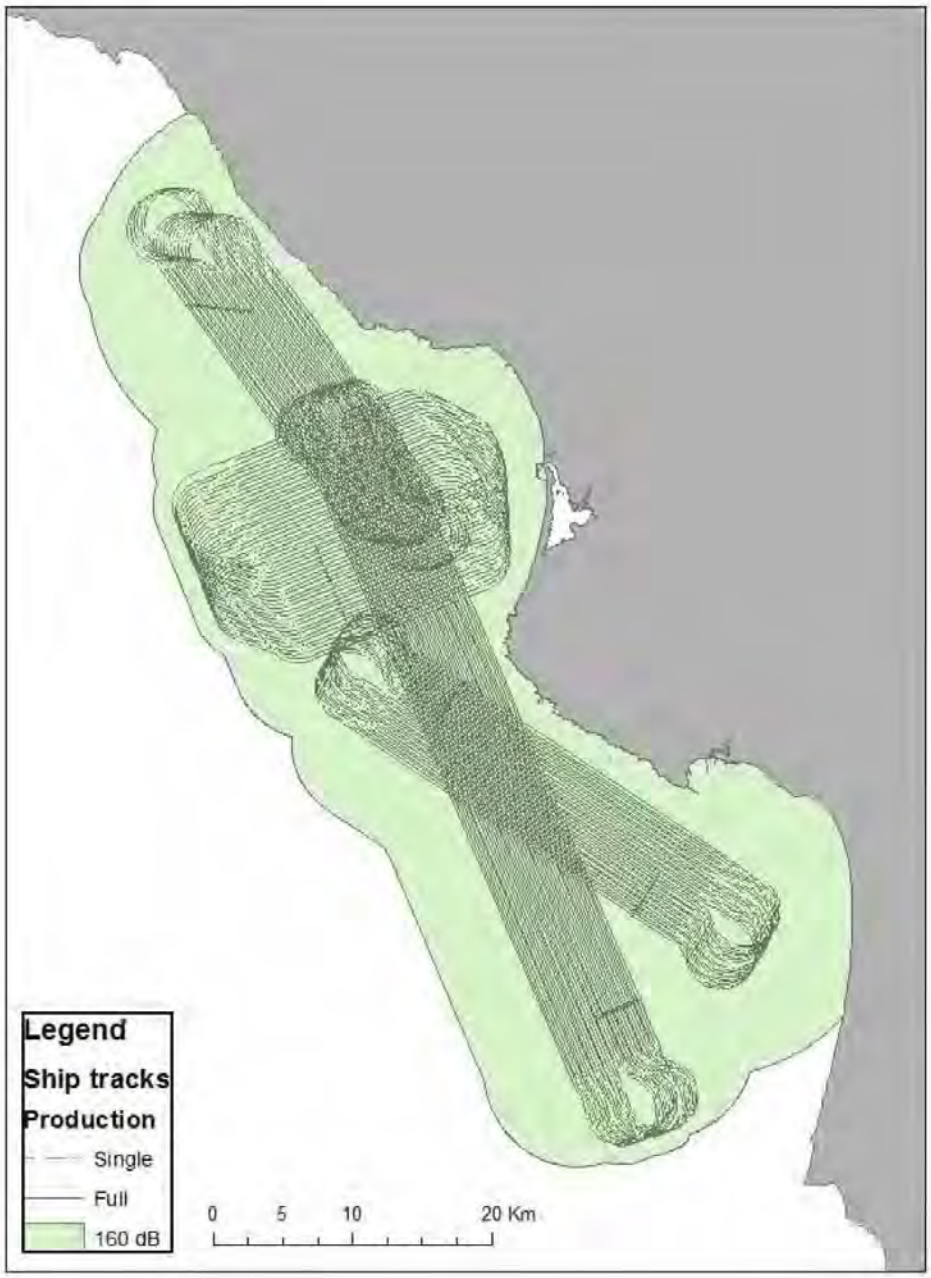


Figure 3.10 Area ensonified by all active acoustic sources combined during proposed Project survey after application of NMFS Level B threshold.

3.9.3. Proportion of mysticetes foraging versus migrating

Calculation of Level B takes using the Probabilistic Disturbance rms approach required an estimate of proportion of mysticetes migrating versus foraging. Appropriate data were available for blue whales. Bailey et al. (2010) provided satellite tag data from 56 blue whales tagged initially in the Santa Barbara basin to calculate the proportion of time animals spent in area-restricted search (ARS) or foraging versus time spent migrating. Values for each month were 0.421 for September, 0.346 for October and 0.313 for November (resulting seasonal average = 0.360). This seasonal average (36% of time) was used as an estimate of proportion of time spent by all mysticetes foraging.

3.9.4 Density variability scenarios

Three density scenarios were incorporated into the take estimates to explore the impact of variability on take assessments. The '**Base**' density was derived from the mean densities provided in Table 3.1. The '**Upper**' density estimate was derived from incorporating a correction factor based on the SERDP-SDSS upper 90% confidence intervals or one standard deviation based on reported CVs (Koski et al. 1998). A third density scenario was developed aiming to recognize some of the limitations of using a static density estimate based on large-scale habitat-predictions. For this '**Potential**' density estimate, a correction factor (2.3) was applied to the humpback whales SERDP-SDSS Model density, derived from validations undertaken by Barlow et al. (2009) to take into account SERDP-SDSS model underestimates (compared to line transect estimates) for the area. The Potential density estimate also applied a conservative species-related turnover factor, incorporated to take into account local area net positive immigration (new animals entering or passing through the ensonification area). Turnover rates for resident species (e.g., harbor porpoise and harbor seal) were assumed to be 1 (i.e., no turnover). Data from satellite tags deployed on 139 blue whales indicated mean time within a foraging patch as 21 days (Bailey et al. 2010). This represent an estimate of turnover rate of 2.5 times over the length of the survey and was applied to all mysticete species. Turnover is likely larger for some migrating species, but we have assumed this level of large scale movement is to a greater extent captured within the SERDP-SDSS density estimates. A conservative estimated turnover value of 1.25 was applied to the remaining species (Table 3.11).

3.9.5 Behavioral Avoidance Response (BAR)

Ramp-up has become a standard mitigation measure for seismic operations in many areas. This has occurred in recognition of the potential risk that immediate hearing damage could occur to a nearby marine mammal if a high-energy sound source, such as an airgun array, were turned on suddenly. The ramp-up procedure in this survey plans to ramp up to full operating levels starting with the smallest airgun and adding power at a rate of approximately 6 dB per 5 minute period (time period estimated to be 30 minutes). The assumption with this mitigation measure is that marine mammals will find the sound aversive and the ramp up period will give animals adequate time to move away before hearing damage or physiological effects occur (Richardson et al. 1995). However, the ramp-up procedure is currently implemented as a common sense approach, and there is little information on its efficacy in evoking an appropriate response from marine mammals. For example, Stone and Tasker (2006) noted no difference in the distance of cetaceans from seismic arrays when systems were ramping up (compared to periods when airguns were off or in full operation); though for both small odontocetes and mysticetes more animals were seen heading away from the vessel than any other direction. Clear

movement away has been observed for some species, like Atlantic spotted dolphins, *Stenella frontalis.* In contrast, some species may avoid a disturbance vertically rather than horizontally; that is, by surfacing or diving, which may leave them more vulnerable to certain acoustic or other impacts (such as ship collision).

The assumption is also often made that operational airguns will also cause animals to move away and minimize the risk or chance of level A harassment. Stone and Tasker (2006) reported on observations undertaken during 201 seismic surveys in UK and adjacent waters and results demonstrate small odontocetes showed the strongest lateral spatial avoidance (extending at least as far as the limit of visual observation) in response to active airguns, while mysticetes and killer whales showed more localized spatial avoidance. Sections 2.0 and 3.6 highlight the large differences in behavioral sensitivity, highlighting the lower tolerance level of porpoise and beaked whales, as well as the importance of context (e.g., foraging or not).

While temporary avoidance of intense noise like air guns appears the most likely reaction, review of studies assessing the need to shut-down or power-down during a seismic survey indicate there are instances where an animal has not moved away and has or is about to enter the pre-determined noise exclusion zone (of a size related typically to the 180 dB re: 1 µPa (rms) level). Relevant information for species inhabiting California waters were compiled from observations during three USGS small scale seismic surveys. In summer 1998, during a 13 day cruise of the California Bight shut downs were made for 8 Common dolphins and 3 California sea lions. Headings of 27 of 129 sightings were observed moving towards the vessel (Calambokidis et al. 1998). During 19 days in summer 2000, also in the California Bight, shut downs were made for 29 Common dolphins, 3 Risso's Dolphins, 4 bottlenose dolphins, 3 California sea lions and 1 blue whale (Calambokidis and Chandler 2000). In summer 2002, during 14 days in the Santa Barbara channel, shut downs were made when using a high power source for 20 Common dolphins, 1 Risso's Dolphin, 10 Pacific white-sided dolphins, 2 California sea lions, 4 humpback whales and 1 blue whale (Calambokidis et al. 2002b). Stone and Tasker (2006) documented 6.8% of cetaceans were observed heading towards seismic survey vessel firing large arrays, of which ~75% were observed within 2km. Overall, complete avoidance of Level A levels of intense noise do not appear to occur consistently.

Based on the USGS shut-down data above , the review made in Sections 2.0 and 3.5 and harbor porpoise reactions observed by Brandt et al. (2011) to pulsed sounds, we applied a reasonable estimate for a behavioral response level of likelihood for avoiding the assumed 180 dB re: 1 µPa (rms) exclusion zone. Based on the aggregate scientific information that is available, a **behavioral avoidance response** (BAR) value of 0.99 was selected for porpoise and beaked whales (identified as particularly sensitive species by Southall et al. (2007), and a value of 0.90 selected for all other remaining species. Application of a behavioral avoidance response decreased the estimated number of Level A takes, but consequently Level B takes were increased accordingly. A coarse sensitivity analysis was undertaken assessing impact of lowering the BAR.

3.9.6 Effectiveness of Marine Mammal Observers and PAM (Level A only)

Marine Mammal Observers (MMOs) on the scout vessel and the survey vessel and initially on the aircraft would be used to monitor the exclusion zone. Passive acoustic monitoring (PAM) would also be in operation. A proportion of animals predicted to co-occur within the Level A radii should be detected, causing subsequent power down (or shut down) and reduction in the predicted take estimate.

The proportion of time MMOs are able to observe for will vary over the survey. We have assumed a 12 h. visual monitoring day on average (Civil twilight starts 6.38am, ends 6.28pm on October 20th in the Investigation area). Quantitative values for probability of detection if an animal is within the prescribed exclusion zone (an average of ~1km based on Greenridge and Jasco Applied Sciences models) are not available for most species, and where available, would depend upon sea conditions and visibility, among other factors. Estimates listed in Table 3.11 are qualitative estimates from experienced field biologists working on these species in many areas. Data was derived for an Environmental Assessment conducted in support of NMFS permit #14534 for biological and behavioral response studies in southern California. The estimates are based upon the size of the individual (the larger the animal, the more likely to detect), the size of the group (the larger the group, the more likely to detect), the frequency of surfacing, and the visibility of surface behavior. These estimates for the distance at which sensitive and hard-to-sight species (e.g., beaked whales) are detected also take monitoring for vocalizations into account. Daylight detection probabilities are considered maximums, taking into account the use of MMOs on two vessels and the proposed use of PAM (Table 3.11). Detection probabilities will likely decrease if the survey continues in poor weather, increasing Level A takes.

3.9.7 Sea otter takes

Assessment of potential takes on sea otters required an alternative technique, given their limited distribution and a review of potential stressors. Malme et al. (1984) did not find any disturbance response or change in foraging behavior in sea otters exposed to seismic airgun noise. Typical distance from the otters being observed and the sound source was 1.3 – 1.6 km. On one occasion this distance was as close at 900m. Nevertheless, an acoustic take was still computed using the 180 dB re: 1 µPa rms isopleths with the final take compared against the minimum population estimate as sea otter behavior (e.g., surface rafting) allows for minimization of acoustic injury. We used the maximum 180 dB re: 1 µPa rms radius from Jasco Applied Sciences (Appendix I) for production lines (856 m) and mitigation turns (46 m) to buffer the survey tracks. We also calculated a take level based on the potential disturbance effect from the physical presence of vessels on sea otters. Udevitz et al. (1995) compared detection probabilities of sea otters by boat based and land based observers within a 200 m (100 m either side of) swath of the boat's path. They report that 30% of the otters detected by land based observers were not seen by boat based observers. Of those 30% missed by boat observers, 53% were not detected because they left the transect segment while the rest either dove or evaded detection in another way. We therefore applied a conservative approach to otter disturbance due to vessel presence, namely that 30% of otters within 100 m of a vessel would be disturbed.

To estimate the number of otters disturbed in the above manners we utilized the USGS Western Ecological Research Center's Spring 2010 survey results. These GIS data present sea otter densities in polygons along the California coastline. These polygons are roughly 500 meters wide and stretch out to the 60 meter isobath and are further divided between those areas <30m and those >30m. Using ArcGIS 10 we overlaid the buffer areas for the acoustic and physical presence takes with the USGS otter density polygons. These areas were multiplied by the reported otter density in each polygon and summed to estimate the total number of otters that would be within 100m (for boat presence) and 856m for the airgun array of the seismic survey vessel. Thirty percent of the physical presence takes were assumed to be animals that were disturbed. Otter densities were also calculated within the area proposed for placement of offshore geophone lines as interactions with vessels undertaking this task will probably occur.

Table 3.11 Biological context and correction factors used in take analysis of candidate species. See text for details. Southall functional hearing groups as follows; LFC: low frequency cetaceans, MFC: mid frequency cetaceans, HFC: high frequency cetaceans, Pw: pinnipeds in water

Species	Minimum Population	Residual PBR	Depth dependent density cut offs	Upper density weighting factor	Noise behavioral avoidance response	MMO detection success	Turnover estimate for Potential density	Southall et al. (2007) functional hearing group
Fin whale	*2,624*	*15*	*0*	*1.44*	*0.9*	*0.9*	*2.5*	*LFC*
Humpback whale	*1,878*	*7.7*	*0*	*1.68*	*0.9*	*0.9*	*2.5*	*LFC*
Blue whale	*2,046*	*2.1*	*<80m*	*1.63*	*0.9*	*0.9*	*2.5*	*LFC*
Minke whale	202	2	0	1.59	0.9	0.9	2.5	LFC
Short-beaked common dolphin	343,990	3,376	0	1.53	0.9	0.9	1.25	MFC
Long-beaked common dolphin	17,127	151	0	2.91	0.9	0.9	1.25	MFC
Small beaked whale species	2,498	25	<100m	1.55	0.99	0.1	1.25	MFC
Harbor porpoise	1,478	15	>200m	2.26	0.99	0.5	1.0	HFC
Dall's Porpoise	32,106	257	<100m	1.68	0.99	0.5	1.25	HFC
Pacific white-sided dolphin	21,406	178	0	1.53	0.9	0.9	1.25	MFC
Risso's dolphin	4,913	39	0	1.95	0.9	0.9	1.25	MFC
Northern right whale dolphin	6,019	43.2	<100m	1.43	0.9	0.9	1.25	MFC
Bottlenose dolphin - California coastal	290	2.4	1 km offshore	1.43	0.9	0.9	1.25	MFC
Sperm whale	*751*	*1.5*	*<100m*	*1.59*	*0.9*	*0.9*	*1.25*	MFC
Harbor seal	26,667	1,569	0	1.94	0.9	0.5	1.0	Pw
California sea lion	153,337	8,766	0	1.25	0.9	0.5	1.25	Pw

4.0 Results

4.1. Level A acoustic takes

Level A acoustic takes were calculated using the dual-criteria thresholds and the methodologies described above (Injury SEL and NMFS Minimum and Maximum). Three density scenarios were modeled (Base, Upper and Potential). These represent mean densities (Base), mean densities weighted by 90% confidence limits or one Standard Deviation (Upper) and a potential density prediction (Potential) that also aims to reflect conservative animal turnover rates and applies correction factor specifically for humpback whales based on expert comments received in reviews of the SERDP-SDSS Model density estimates. Level A acoustic takes presented in Table 4.1 have also been modified to reflect species-specific water depth density cut-off criteria (Table 3.11), depth dependent density variability (for harbor porpoise), the estimated effectiveness of APMs (mainly detection rates by MMOs, Table 3.11) and an assumed species–specific behavioral avoidance response (Table 3.11) to avoid the zone within the Level A threshold. Gray whales are not included in the acoustic take tables as densities during the proposed time period are expected to be zero and therefore acoustic takes are expected to be close to zero.

Injury SEL takes (green cells, Table 4.1) for the proposed Project have been color-coded to depict magnitude level (based on a comparison with residual PBR). These levels were used in the impact assessment matrices (see Section 4.6) and the potential substantial impact species reviews and were preferentially weighted in the final population level assessment, as they include a time component factor and differences in hearing sensitivity. NMFS Minimum Level A takes for the proposed Project are presented in the blue cells in Table 4.1. NMFS Minimum Level A represents an estimate of the minimum number of individual Level A takes, based on the Project footprint area, with no account taken of any area ensonified more than once by the survey. NMFS Maximum Level A takes represent the total area ensonified, including areas that are ensonified more than once (i.e., including overlapping areas as the survey goes back and forth within the Project footprint). NMFS Maximum takes provide an indication of the potential scale for multiple (repeat) takes (under the assumption of static animals). The ratio of NMFS Maximum to Minimum represents a quantification of how 'intense' the survey is within the Project footprint over the entire course of the proposed survey and can be considered to largely reflect the amount of repeated or multiple exposures.

Tables 4.2-4.3 provide Level A takes for Alternatives 1-2. To assess differences between the proposed Project and the two Alternatives, takes were compared. For each Alternative, the percentage of the proposed Project take was calculated (Table 4.4). Reductions in take compared to the proposed Project are depicted by grey cells.

Table 4.1 **Proposed Project** (Boxes 1, 2, 3, 4) Level A takes of special status species calculated using Injury SEL and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (>100%), orange highlight medium magnitude (50-100%) and yellow low magnitude (10-50%), based on percentage of Residual Potential Biological Removal (PBR). Endangered species are denoted in italics. Take estimates have been modified to take account of group-specific behavioral avoidance responses (range 90-99%) whereby animals avoid the area ensonified to the Level A threshold, as well as detection success of animals entering or within the exclusion zone using MMOs and PAM. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint. Gray whales not included in table as densities expected to be zero during proposed survey period.

		Methodology to calculate number of Level A takes							
Take method	**Residual PBR**	**Injury SEL**			**NMFS Minimum**			**NMFS Maximum**	**Ratio of NMFS Maximum/ Minimum**
Density scenario		**Base**	**Upper**	**Potential**	**Base**	**Upper**	**Potential**	**Base**	
Species									
Fin whale	*15*	2.5	3.6	8.9	0.5	0.8	1.9	5.2	9.9
Humpback whale	*7.7*	1.2	2.0	11.3	0.2	0.4	2.4	2.4	9.9
Blue whale	*2.1*	0.9	1.5	3.8	0.2	0.3	0.8	2.0	10.7
Minke whale	2	0.1	0.1	0.3	<0.1	<0.1	0.1	0.2	9.9
Short-beaked common dolphin	3,376	14.8	22.6	28.3	36.9	56.4	70.5	365.2	9.9
Long-beaked common dolphin	151	0.5	1.3	1.7	1.1	3.3	4.1	11.2	9.9
Small beaked whale species	25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	14.1
Harbor porpoise	15	22.8	51.6	51.6	3.3	7.5	7.5	35.3	10.7
Dall's porpoise	257	0.9	1.5	1.9	0.1	0.2	0.3	1.8	14.1
Pacific white-sided dolphin	178	1.6	2.4	3.0	3.9	6.0	7.5	38.7	9.9
Risso's dolphin	39	0.7	1.3	1.7	1.7	3.3	4.1	16.7	9.9
Northern right whale dolphin	43.2	0.6	0.8	1.0	1.3	1.9	2.4	18.8	14.1
Bottlenose dolphin – CA coastal	2.4	<0.1	<0.1	<0.1	0.6	0.9	1.1	2.7	4.4
Sperm whale	*1.5*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	14.1
Harbor seal	1,569	7.8	15.1	15.1	1.7	3.3	3.3	5.6	3.3
California sea lion	8,766	501.0	626.2	782.7	109.9	137.4	171.7	361.7	3.3

Table 4.2 **Alternative 1** (Boxes 1, 2, 4) Level A takes of special status species calculated using Injury SEL and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (>100%), orange highlight medium magnitude (50-100%) and yellow low magnitude (10-50%), based on percentage of Residual Potential Biological Removal (PBR). Endangered species are denoted in italics. Take estimates have been modified to take account of group-specific behavioral avoidance responses (range 90-99%) whereby animals avoid the area ensonified to the Level A threshold, as well as detection success of animals entering or within the exclusion zone using MMOs and PAM. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint.

		Methodology to calculate number of Level A takes							
Take method	**Residual PBR**	**Injury SEL**			**NMFS Minimum**			**NMFS Maximum**	**Ratio of NMFS Maximum/ Minimum**
Density scenario		**Base**	**Upper**	**Potential**	**Base**	**Upper**	**Potential**	**Base**	
Species									
Fin whale	*15*	2.1	3.0	7.6	0.5	0.7	1.6	4.3	9.5
Humpback whale	*7.7*	1.0	1.7	9.6	0.2	0.4	2.1	2.0	9.5
Blue whale	*2.1*	0.8	1.2	3.1	0.2	0.3	0.7	1.7	10.0
Minke whale	2	0.1	0.1	0.3	<0.1	<0.1	0.1	0.1	9.5
Short-beaked common dolphin	3,376	12.2	18.7	23.3	32.0	48.8	61.0	304.6	9.5
Long-beaked common dolphin	151	0.4	1.1	1.4	1.0	2.9	3.6	9.4	9.5
Small beaked whale species	25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	13.2
Harbor porpoise	15	18.6	42.1	42.1	2.8	6.3	6.3	28.7	10.4
Dall's porpoise	257	0.7	1.2	1.5	0.1	0.2	0.2	1.5	13.2
Pacific white-sided dolphin	178	1.3	2.0	2.5	3.4	5.2	6.5	32.3	9.5
Risso's dolphin	39	0.6	1.1	1.4	1.5	2.9	3.6	13.9	9.5
Northern right whale dolphin	43.2	0.5	0.7	0.8	1.2	1.7	2.1	15.6	13.2
Bottlenose dolphin – CA coastal	2.4	<0.1	<0.1	<0.1	0.5	0.7	0.8	2.3	4.9
Sperm whale	*1.5*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	13.2
Harbor seal	1,569	6.7	12.9	12.9	1.5	2.9	2.9	4.7	3.1
California sea lion	8,766	426.0	532.4	665.5	95.8	119.8	149.7	301.5	3.1

Table 4.3 **Alternative 2 (Zones 1 and 2)** Level A takes of special status species calculated using Injury SEL and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (>100%), orange highlight medium magnitude (50-100%) and yellow low magnitude (10-50%), based on percentage of Residual Potential Biological Removal (PBR). Endangered species are denoted in italics. Take estimates have been modified to take account of group-specific behavioral avoidance responses (range 90-99%) whereby animals avoid the area ensonified to the Level A threshold, as well as detection success of animals entering or within the exclusion zone using MMOs and PAM. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint. Notes: [1] Excluding Echosounder and Sub-bottom profiler

		Methodology to calculate number of Level A takes							
Take method	**Residual PBR**	**Injury SEL[1]**			**NMFS Minimum**			**NMFS Maximum [1]**	**Ratio of NMFS Maximum/ Minimum**
Density scenario		**Base**	**Upper**	**Potential**	**Base**	**Upper**	**Potential**	**Base**	
Species									
Fin whale	*15*	0.7	1.0	2.4	0.5	0.8	1.9	2.0	3.8
Humpback whale	*7.7*	0.3	0.5	3.1	0.2	0.4	2.4	0.9	3.8
Blue whale	*2.1*	0.3	0.5	1.3	0.2	0.4	1.0	0.9	3.9
Minke whale	2	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	3.8
Short-beaked common dolphin	3,376	7.6	11.6	14.5	36.6	55.9	69.8	140.9	3.8
Long-beaked common dolphin	151	0.2	0.7	0.9	1.1	3.3	4.1	4.3	3.8
Small beaked whale species	25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3.8
Harbor porpoise	15	1.1	2.5	2.5	1.8	4.0	4.0	7.1	4.0
Dall's porpoise	257	0.1	0.2	0.2	0.2	0.3	0.4	0.7	3.8
Pacific white-sided dolphin	178	0.8	1.2	1.5	3.9	5.9	7.4	14.9	3.8
Risso's dolphin	39	0.3	0.7	0.8	1.7	3.3	4.1	6.4	3.8
Northern right whale dolphin	43.2	0.4	0.5	0.7	1.8	2.6	3.2	6.9	3.8
Bottlenose dolphin – CA coastal	2.4	0	0	0	0	0	0	0.0	n/a
Sperm whale	*1.5*	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	3.8
Harbor seal	1,569	1.2	2.4	2.4	1.3	2.5	2.5	1.8	1.4
California sea lion	8,766	79.6	99.5	124.3	83.8	104.7	130.9	113.7	1.4

Table 4.4 Percent of each Alternative (A) Level A take compared with the proposed Project (P) Level A take, for Injury SEL, NMFS Minimum and NMFS Maximum methods. Cells color shaded in grey indicate a reduction in take compared to the proposed Project. Notes: [1] Excluding Echosounder and Sub-bottom profiler

Take method	**Injury SEL**		**NMFS Minimum**		**NMFS Maximum**	
Comparison	**P v A1**	**P v A2[1]**	**P v A1**	**P v A2**	**P v A1**	**P v A2[1]**
Species						
Fin whale	85	27	87	99	83	39
Humpback whale	85	27	87	99	83	39
Blue whale	81	33	88	126	82	45
Minke whale	85	27	87	99	83	39
Short-beaked common dolphin	82	51	87	99	83	39
Long-beaked common dolphin	82	51	87	99	83	39
Small beaked whale species	83	66	89	136	83	37
Harbor porpoise	82	5	84	53	81	20
Dall's porpoise	78	12	89	136	83	37
Pacific white-sided dolphin	82	51	87	99	83	39
Risso's dolphin	82	51	87	99	83	39
Northern right whale dolphin	83	66	89	136	83	37
Bottlenose dolphin - CA coastal	71	0	77	0	86	0
Sperm whale	83	66	89	136	83	37
Harbor seal	86	16	87	76	83	31
California sea lion	85	16	87	76	83	31
All species average	82	35	87	98	83	34

4.2 Level B acoustic takes

Level B acoustic takes were calculated using the dual-criteria thresholds and the methodologies described above (Probabilistic Disturbance rms NMFS Minimum and Maximum). Three density scenarios have been modeled (Base, Upper and Potential). These represent mean densities (Base), mean densities weighted by 90% confidence limits or one Standard Deviation (Upper) and a potential density prediction (Potential) that also aims to reflect conservative animal turnover rates and applies correction factor specifically for humpback whales based on expert comments received in reviews of the SERDP-SDSS Model density estimates. Level B acoustic takes presented in Table 4.5 have also been modified to reflect species-specific water depth density cut-off criteria (Table 3.11), depth dependent density variability (for harbor porpoise) and are increased to reflect assumed species–specific behavioral avoidance response to avoid the zone within the Level A threshold. Gray whales are not included in the acoustic take tables as densities during the proposed time period are expected to be zero and therefore acoustic takes are expected to be close to zero.

Probabilistic Disturbance rms takes (green cells, Table 4.5) for the proposed Project have been color-coded to depict magnitude level (based on a comparison with the minimum population estimate). These levels were used in the impact assessment matrices (see Section 4.4) and the potential substantial impact species reviews and were preferentially weighted in the final population level assessment, as they take into account context and variability in hearing and response sensitivity. NMFS Minimum Level B takes for the proposed Project are presented in the blue cells in Table 4.5. NMFS Minimum Level B represents an estimate of the minimum number of individual Level B takes, based on the Project footprint area, with no account taken of any area ensonified more than once by the survey. NMFS Maximum Level B takes represent the total area ensonified, including areas that are ensonified more than once (i.e., including overlapping areas as the survey goes back and forth within the Project footprint). NMFS Maximum takes provide an indication of the potential scale for multiple (repeat) takes (under the assumption of static animals). The ratio of NMFS Maximum to Minimum represents a quantification of how 'intense' the survey is within the Project footprint and can be considered to largely reflect the amount of repeated or multiple exposures.

Tables 4.6-4.7 provide Level B takes for Alternatives 1-2. To assess differences between the proposed Project and the two Alternatives, takes were compared. For each Alternative, the percentage of the proposed Project take was calculated (Table 4.8). Reductions in take compared to the proposed Project are depicted by grey cells.

Table 4.5 **Proposed Project** Level B takes of special status species calculated using Probabilistic Disturbance rms and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (Listed species >2.5%, non-listed species >25%), orange highlight medium magnitude (Listed species 1.25-2.5%, non-listed species >15-25%) and yellow low magnitude (Listed species >1 individual, non-listed species 5-15%), based on percentage of minimum population estimate. Endangered species are denoted in italics. Take estimates have been modified to include group-specific behavioral avoidance responses whereby animals avoid the Level A threshold area. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint. Gray whales not included in table as densities expected to be zero during proposed survey period.

		Methodology to calculate number of Level B takes							
Take method	**Minimum population estimate**	**Probabilistic Disturbance rms**			**NMFS Minimum**			**NMFS Maximum**	**Ratio of NMFS Maximum/ Minimum**
Density scenario		**Base**	**Upper**	**Potential**	**Base**	**Upper**	**Potential**	**Base**	
Species									
Fin whale	*2,624*	77.6	112.1	280.4	14.4	20.8	51.9	484.4	33.7
Humpback whale	*1,878*	36.5	61.4	353.0	6.8	11.4	65.4	227.7	33.7
Blue whale	*2,046*	38.3	62.4	156.0	4.8	7.8	19.6	137.1	28.6
Minke whale	202	2.5	3.9	9.7	0.5	0.7	1.8	15.3	33.7
Short-beaked common dolphin	343,990	1047.1	1597.9	1997.4	1012.1	1544.5	1930.6	34116.8	33.7
Long-beaked common dolphin	17,127	32.2	93.8	117.2	31.1	90.6	113.3	1049.9	33.7
Small beaked whale species	2,498	50.9	78.8	98.4	2.9	4.4	5.6	61.9	21.6
Harbor porpoise	1,478	1438.6	3256.4	3256.4	734.1	1661.7	1661.7	19379.5	26.4
Dall's porpoise	32,106	270.4	454.4	568.0	26.8	45.0	56.2	577.1	21.6
Pacific white-sided dolphin	21,406	111.0	169.8	212.2	107.3	164.1	205.1	3616.6	33.7
Risso's dolphin	4,913	47.8	93.4	116.8	46.2	90.3	112.9	1557.5	33.7
Northern right whale dolphin	6,019	44.3	63.5	79.4	35.6	51.0	63.8	784.0	22.0
Bottlenose dolphin - CA coastal	290	19.8	28.3	35.4	41.4	59.2	74.1	1838.4	44.4
Sperm whale	*751*	0.8	1.2	1.5	0.6	1.0	1.2	13.3	22.0
Harbor seal	26,667	48.7	94.5	94.5	38.8	75.2	75.2	1279.8	33.0
California sea lion	153,337	3137.4	3921.8	4902.3	2496.0	3120.0	3900.0	82392.8	33.0

Table 4.6 **Alternative 1** Level B takes of special status species calculated using Probabilistic Disturbance rms and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (Listed species >2.5%, non-listed species >25%), orange highlight medium magnitude (Listed species 1.25-2.5%, non-listed species >15-25%) and yellow low magnitude (Listed species >1 individual, non-listed species 5-15%), based on percentage of minimum population estimate. Endangered species are denoted in italics. Take estimates have been modified to include group-specific behavioral avoidance responses whereby animals avoid the Level A threshold area. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint.

		Methodology to calculate number of Level B takes							
Take method	**Minimum population estimate**	**Probabilistic Disturbance rms**			**NMFS Minimum**			**NMFS Maximum**	**Ratio of NMFS Maximum/ Minimum**
Density scenario		**Base**	**Upper**	**Potential**	**Base**	**Upper**	**Potential**	**Base**	
Species									
Fin whale	*2,624*	72.9	105.3	263.3	12.9	18.6	46.6	337.9	26.2
Humpback whale	*1,878*	34.3	57.7	331.5	6.1	10.2	58.6	158.8	26.2
Blue whale	*2,046*	35.9	58.6	146.5	4.2	6.9	17.3	92.8	21.9
Minke whale	202	2.3	3.7	9.1	0.4	0.6	1.6	10.7	26.2
Short-beaked common dolphin	343,990	925.7	1412.7	1765.8	908.2	1385.9	1732.4	23798.4	26.2
Long-beaked common dolphin	17,127	28.5	82.9	103.6	27.9	81.3	101.7	732.4	26.2
Small beaked whale species	2,498	46.5	71.9	89.9	2.5	3.9	4.9	34.2	13.5
Harbor porpoise	1,478	1381.4	3127.0	3127.0	670.0	1516.7	1516.7	13240.1	19.8
Dall's porpoise	32,106	251.4	422.5	528.2	23.6	39.6	49.5	318.4	13.5
Pacific white-sided dolphin	21,406	98.1	150.1	187.6	96.3	147.3	184.1	2522.8	26.2
Risso's dolphin	4,913	42.3	82.6	103.2	41.5	81.0	101.3	1086.5	26.2
Northern right whale dolphin	6,019	39.2	56.2	70.3	31.4	44.9	56.2	449.5	14.3
Bottlenose dolphin - CA coastal	290	17.1	24.5	30.6	37.4	53.4	66.8	1420.2	38.0
Sperm whale	*751*	0.7	1.1	1.3	0.5	0.8	1.1	7.6	14.3
Harbor seal	26,667	43.5	84.3	84.3	34.8	67.4	67.4	1023.7	29.4
California sea lion	153,337	2798.5	3498.1	4372.6	2238.3	2797.9	3497.3	65904.2	29.4

Table 4.7 **Alternative 2** Level B takes of special status species calculated using Probabilistic Disturbance rms and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (Listed species >2.5%, non-listed species >25%), orange highlight medium magnitude (Listed species 1.25-2.5%, non-listed species >15-25%) and yellow low magnitude (Listed species >1 individual, non-listed species 5-15%), based on percentage of minimum population estimate. Endangered species are denoted in italics. Take estimates have been modified to include group-specific behavioral avoidance responses whereby animals avoid the Level A threshold area. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint.

		Methodology to calculate number of Level B takes							
Take method	**Minimum population estimate**	**Probabilistic Disturbance rms**			**NMFS Minimum**			**NMFS Maximum[1]**	**Ratio of NMFS Maximum/ Minimum**
Density scenario		**Base**	**Upper**	**Potential**	**Base**	**Upper**	**Potential**	**Base**	
Species									
Fin whale	*2,624*	74.2	107.2	268.0	16.0	23.1	57.8	250.5	15.7
Humpback whale	*1,878*	34.9	58.7	337.4	7.5	12.6	72.7	117.7	15.7
Blue whale	*2,046*	36.9	60.2	150.6	6.3	10.3	25.7	94.4	15.0
Minke whale	202	2.3	3.7	9.3	0.5	0.8	2.0	7.9	15.8
Short-beaked common dolphin	343,990	927.2	1415.0	1768.8	1126.2	1718.6	2148.3	17,641.0	15.7
Long-beaked common dolphin	17,127	28.5	83.0	103.8	34.7	100.9	126.1	542.9	15.6
Small beaked whale species	2,498	49.9	77.2	96.5	3.9	6.1	7.6	51.1	13.1
Harbor porpoise	1,478	1303.3	2950.3	2950.3	595.5	1347.9	1347.9	5,386.0	9.0
Dall's porpoise	32,106	268.1	450.6	563.2	36.4	61.2	76.5	475.8	13.1
Pacific white-sided dolphin	21,406	98.3	150.4	188.0	119.4	182.6	228.3	1870.1	15.7
Risso's dolphin	4,913	42.3	82.7	103.4	51.4	100.5	125.6	805.4	15.7
Northern right whale dolphin	6,019	43.6	62.5	78.2	48.5	69.4	86.8	660.5	13.6
Bottlenose dolphin - CA coastal	290	13.5	19.2	24.0	32.8	46.9	58.6	335.8	10.2
Sperm whale	*751*	0.7	1.2	1.5	0.8	1.3	1.6	11.2	14.0
Harbor seal	26,667	45.5	88.3	88.3	43.6	84.6	84.6	663.6	15.2
California sea lion	153,337	2928.7	3660.9	4576.1	2808.8	3511.0	4388.8	42,719.0	15.2

1 Excludes Echosunder or Sub-bottom profiler

Table 4.8 Percent of each Alternative (A) Level B take compared with the proposed Project (P) Level B take, for Probabilistic Disturbance rms, NMFS Minimum and NMFS Maximum methods. Cells color shaded in grey indicate a reduction in take compared to the proposed Project. Notes: [1] Excluding Echosounder and Sub-bottom profiler

Take method	**Probabilistic Disturbance rms**		**NMFS Minimum**		**NMFS Maximum**	
Comparison	**P v A1**	**P v A2**	**P v A1**	**P v A2**	**P v A1**	**P v A2[1]**
Species						
Fin whale	94	96	90	111	70	52
Humpback whale	94	96	90	110	70	52
Blue whale	94	97	88	131	68	69
Minke whale	94	96	80	100	70	52
Short-beaked common dolphin	88	89	90	111	70	52
Long-beaked common dolphin	88	89	90	112	70	52
Small beaked whale species	91	98	86	134	55	83
Harbor porpoise	96	91	91	81	68	28
Dall's porpoise	93	99	88	136	55	82
Pacific white-sided dolphin	88	89	90	111	70	52
Risso's dolphin	88	89	90	111	70	52
Northern right whale dolphin	89	98	88	136	57	84
Bottlenose dolphin - CA coastal	87	68	90	79	77	18
Sperm whale	89	98	83	133	57	84
Harbor seal	89	93	90	112	80	52
California sea lion	89	93	90	113	80	52
All species average	**91**	**92**	**88**	**114**	**68**	**57**

4.3 Acoustic take overview

Take estimates varied across methodologies and density scenarios, particularly for Level B results. Takes were used to determine magnitude level for input into severity ratings.

4.3.1. Level A takes

Project Level A takes and resulting magnitude ratings were consistently higher for Injury SEL Level A for fin, humpback and blue whales, as well as harbor porpoise compared to NMFS Minimum takes. NMFS Minimum takes were higher for mid-frequency cetaceans (Table 4.1).

For the Project, under the assumed 99% avoidance response, harbor porpoise (23 to 52) exceeded the high magnitude criteria for Level A (>100% of residual PBR) for Injury SEL at all density scenarios, but remained at low magnitude using NMFS Minimum methods. Under the assumed 90% avoidance responses, both humpback (11) and blue (4) whale takes exceeded the high magnitude criteria for Injury SEL at the Potential density scenario. Both methods predicted high numbers of California sea lion Level A takes (Table 4.1), albeit a fraction of their residual PBR. For NMFS Minimum takes, no species exceeded low magnitude levels. NMFS Minimum takes of endangered mysticete were below 1 animal at Base densities and ~1-2 at Potential densities. NMFS Maximum levels were 9.9-14.1 times that of NMFS Minimum estimates for cetaceans and 3.3 times for pinnipeds (reflecting the higher Level A dB threshold criteria for pinnipeds). This ratio potentially can be considered to largely reflect the amount of repeated or multiple exposures, if animals remain within the area of ensonification throughout the survey and no new ones enter the area (Table 4.1). The Potential density scenario aims to incorporate a modest turnover of animals during the Project duration.

Sensitivity analyses on our noise BAR, and to a smaller extent, MMO detection success assumptions, (Table 3.11) especially influenced harbor porpoise takes. For example, high magnitude levels (>100% residual PBR) for NMFS Level A Minimum takes at Base density were exceeded for harbor porpoises if BAR was reduced from 0.99 to 0.95. Similarly, high magnitude was exceeded for Coastal bottlenose dolphin at BAR of 0.60. At low 0.50 BAR levels, endangered mysticete NMFS Level A takes were 1 animal for blue whale and humpback whale and 2.6 animals for fin whale, with 165 harbor porpoises estimated to be taken. Takes were less sensitive to changes in MMO detection success, with no high magnitude ratings reached if a 50% reduction in assumed detection success values was applied (Table 3.11). For Injury SEL takes at Base densities, a reduction to 0.5 BAR resulted in Level A takes of 5 blue whales (high magnitude), 6 humpback whales, 12 fin whales and 1139 harbor porpoise (high magnitude).

Level A magnitude ratings were close to identical for Alternative 1 (Table 4.2), despite takes being 82-87% of that of the Project (Table 4.4). No high magnitude ratings were found for Alternative 2 (Table 4.3), with only one moderate magnitude for Alternative 2 (blue whales at Potential densities). Injury SEL takes for Alternative 2 represented on average 35% of the Project take, with relatively large decreases in takes for porpoises, bottlenose dolphins and the pinnipeds. Injury SEL takes for Alternative 2 did not include the contribution for the echosounder and sub-bottom profiler, but this only explains a small part of the difference. Cumulative 24 hour SEL estimates (based on data from Box 1) using data for airguns only represented 99.7% of the combined active sources area for low frequency cetaceans, 91.4% for mid frequency cetaceans, 84.3% for high frequency cetaceans and 97.7% for pinnipeds. Importantly, correction of Alternative 2 Injury SEL takes to account for this level of additional SEL contribution of the echosounder and sub-bottom profiler made no changes to reported magnitude ratings. Differences in NMFS Minimum estimates between Alternative 2 and the Project varied by species with takes of deeper

water restricted species increasing by 26-36% and porpoises, bottlenose dolphins and the pinnipeds decreasing. Results reflect differences in size and the location across surveys. NMFS maximum takes for Alternatives 2 were approximately one third that of the Project, highlighting the Projects relatively high number of tracks per km^2 compared to Alternative 2.

4.3.2 Level B takes

Project Level B Probabilistic Disturbance rms takes and resulting magnitude levels were considerably higher than NMFS Minimum takes for endangered mysticete, however both methods resulted in high magnitudes for harbor porpoises (Table 4.5). Under assumed model conditions and responses, combined Probabilistic Disturbance rms take estimates exceeded the high magnitude criteria for harbor porpoise and all three endangered mysticete at Upper and Potential density scenarios and for fin whale alone at base density. Probabilistic Disturbance rms takes across density scenarios ranged from 77-280 for fin whales, 37-353 for humpback whales, 38-156 for blue whales and 438-3256 for harbor porpoises. These Probabilistic Disturbance rms estimates amounted to a 97-100+% of the porpoise population (minimum estimate), 3-11% of the fin whale population, 2-19% of the humpback whale population and 2-8% of the blue whale population (depending on the density scenario).

The Probabilistic Disturbance rms approach set a 10% probability of response for migrating mysticete at the M-weighted 120 dB re: 1 µPa (rms) isopleths. The resulting area amounted to 40-45% of the total take calculated for mysticete, as a predictable function of the large areas ensonified at these levels. The removal of this lower level isopleths for migrating mysticete from the takes still resulted in high magnitude at Potential densities, as well as Upper densities for fin whales. Similarly, this approach predicted that 50% of the particularly sensitive species group (porpoises and beaked whales) will be behaviorally disturbed at the M-weighted 120 dB re: 1 µPa (rms) isopleths. This ensonification area subsequently represented a large proportion of total takes for beaked whales (70%), Dall's porpoise (72%) and harbor porpoise (30%). The removal of this lower level isopleths for harbor porpoise still results in high magnitude at all density scenarios. The assumption that a percentage of animals have behavioral reactions at relatively low threshold levels is a critical part of any comparison across methodologies.

Project take estimates for NMFS Minimum methods also exceeded high magnitude criteria for Level B for harbor porpoise under all density scenarios (ranging between 50-100+% of population). NMFS Minimum take estimates exceeded high magnitude criteria for Level B for humpback whales (3.9% of the population) only at Potential densities. Fin and blue whales were moderate magnitude in this Potential density scenario, i.e., <2.5% of population). Medium magnitude criteria were also reached for California Coastal bottlenose dolphin for Upper and high magnitude at Potential densities. Notably, for harbor porpoise Probabilistic Disturbance rms takes equate to 70-100+% of the best population estimate and NMFS Minimum Level B takes equate to 36-81% of the best population estimate in comparison.

NMFS Maximum takes levels for the Project were ~22-34 times that of NMFS Minimum take estimates for all species except bottlenose dolphin (for which the ratio was 44). This ratio highlights the intensity of the repetitive shooting within the proposed survey and the large overlap across production runs. It also includes the 25% contingency factor for reshot production lines. Repeat exposure levels are considered a greatest concern for resident species, such as harbor porpoise and harbor seal.

The Proposed Project and Alternative 1 have relatively larger areas over hard bottom substrate, leading to an increase in noise transmission and increased radii for tracks within this area. The Proposed Project extends furthest along the coast. However, Alternative 2 had the largest NMFS Level B footprint. As a result, Probabilistic Disturbance rms takes for Alternative 1 and 2 averaged 91% and 92% of the Project. NMFS Minimum takes averaged 88% for Alternative 1, but averaged 114% for Alternative 2. In Alternative 2 however, harbor porpoise and bottlenose dolphin takes were reduced compared to the Project (reflecting the more offshore nature of these surveys). NMFS Maximum takes were highest for the Project and least for Alternative 2 (Table 4.8). Despite these differences, magnitude ratings were similar across the Project and the Alternatives. Harbor porpoises remained high magnitude across all methods and Alternatives. Fin, blue and humpback whale were high magnitude at Upper and Potential densities using Probabilistic Disturbance rms methods. Blue whales reduced to moderate magnitude at Probabilistic Disturbance rms Base densities for Alternative 2. NMFS maximum to Minimum ratios were between 9-16 for Alternative 2, illustrating the reduced intensity of this Alternatives compared to the Project.

The inclusion of threshold radii calculated for the echosounder and the sub-bottom profiler typically occurred when the single airgun was in use, but varied by threshold and marine mammal frequency group. In general the MBES was loudest at close distances with the single airgun becoming relatively louder at greater distances. This is due to the louder source level of the MBES and higher frequency content (12 kHz) compared to the single airgun (most energy <1 kHz). Frequency dependent absorption increases with frequency such that the MBES sound is attenuated at a faster rate than the single airgun. Therefore at a certain distance the single airgun sound becomes relatively louder than the MBES even though the MBES started out louder at the source. Under certain depth scenarios and frequency weighting (HFC and pinnipeds in water) the SBP was louder than the single airgun or MBES. This is likely due to the wide frequencies used by the SBP (3.5, 12, 200 kHz).

Using the maximum radius from all active sound sources rather than the airguns alone was assessed for Level B takes in Alternative 2. No changes in the level of magnitude were found. Inclusion of non-airgun sources resulted in small positive increases for NMFS Minimum take estimates, approximately <0.5% across all species. For Probabilistic Disturbance rms, moderate increases were seen for mid-frequency cetaceans (8-9%) excluding porpoises and beaked whales for which increases were <0.1%. The combined Probabilistic Disturbance rms take estimate for pinnipeds increased by 5-6%, and increased by 0.3-0.4% for mysticetes.

4.3.3 Sea otter take analyses

Assessment of NMFS Level B~~A~~ Minimum take and boat disturbance to sea otters resulted in values of 62 and 12 individuals respectively for the proposed Project (Table 4.9). The boat disturbance estimates are for one vessel only. If more vessels will be used for mitigation, then the numbers for boat disturbance should be increased proportionate to the number of vessels present and their proximity to otter habitat. The majority of takes occurred in Buchon Point vicinity, but overlap with the highest density areas of less than 30m depth in this region were relatively small (Figure 4.1). Alternative 1 resulted in a small reduction, but Alternative 2 resulted in larger reductions due to tracklines positioned further away from the coastal fringe where otters reside. For acoustic disturbance, Project and Alternative 1 magnitude ratings were considered Moderate, while Alternative 2 was considered low magnitude.

Approximately 32 km of geophone cables will be laid from a vessel off the DCPP. This area has a high density otters, especially near shore. The total otter habitat encompassed by these geophone cables is

roughly 81 km^2 containing an estimated 173 animals. With a total of five lines to be laid, a moderate magnitude (equivalent of 1.25-2.5% of ESA-listed regional population) rating was appropriate for this stressor.

Table 4.9 Estimates of otter take from Level B~~A~~ acoustic disturbance from acoustic survey (NMFS 180 dB re: 1 µPa rms) and from vessel proximity (30% at 100 m per Udevitz 1995).

Assessment Level	Project	Alternative 1	Alternative 2
Level A NMFS Minimum	61.9	56.3	7.5
Boat at 100m	11.9	11.4	1.4

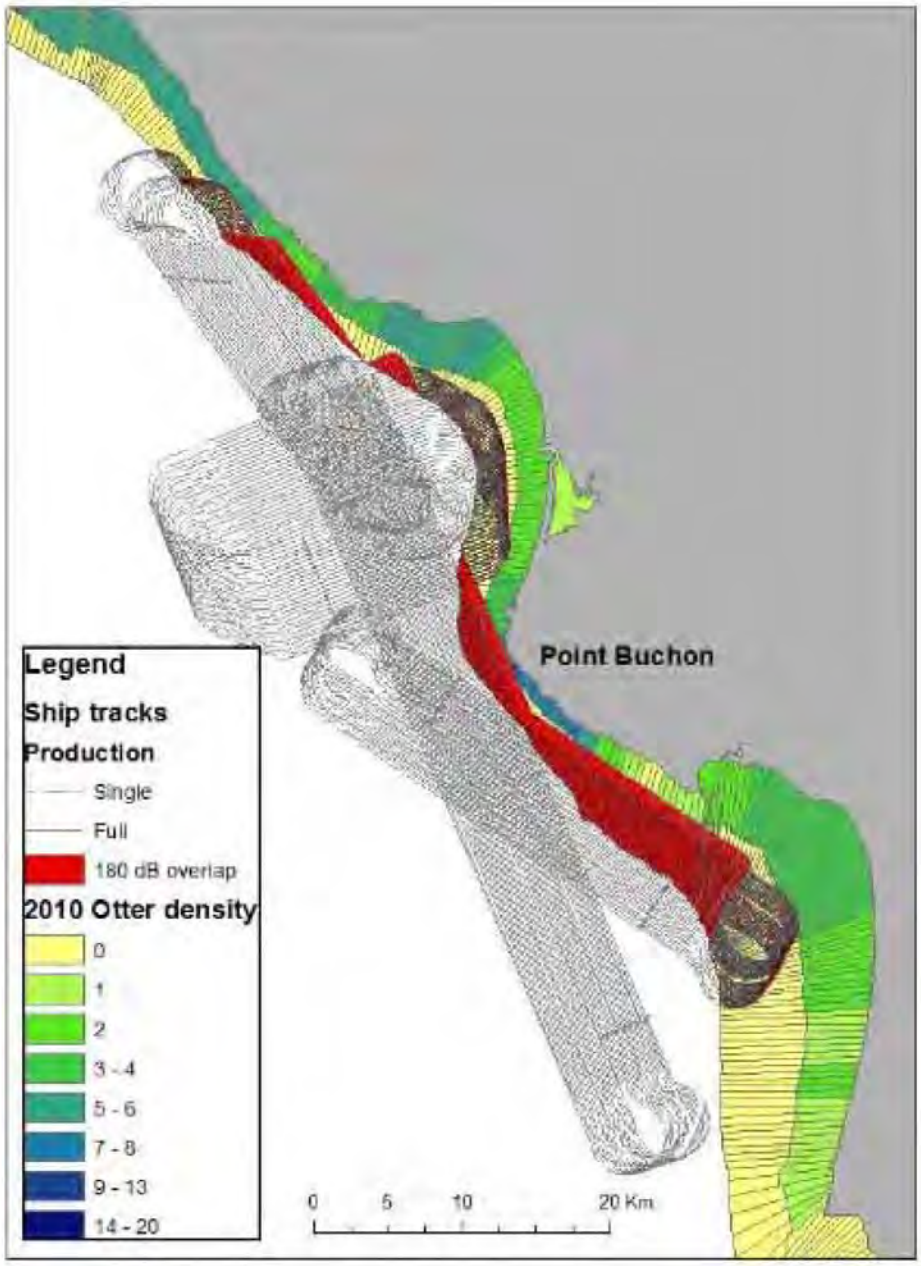


Figure 4.1 Distribution of overlap of sea otter distribution and NMFS Level A thresholds for the Proposed Project. Darker areas represent higher densities of sea otters.

4.4 Impact Analysis

4.4.1 Significance criteria a (NMFS NOAA rms Level B individual takes)

The proposed Project has the potential to affect at least 15 cetacean species, 4 pinnipeds and 1 mustelid using significance criteria a - level A or B harassment takes using NOAA-NMFS (rms) thresholds. Gray whales are considered to have the potential for a level B takes only if the project continues beyond mid-December (i.e. zero density during proposed Project time period). In addition to the candidate species, NMFS Level B takes are predicted to occur at Base densities for striped dolphins, killer whales, elephant seals and northern fur seals.

4.4.2. Significance criteria b-e (substantial adverse effects)

No universally adopted method is available to assess stressor impacts on populations of marine mammals. This report describes the development of a simple matrix assessment approach which aims to identify the potential effects of identified stressors based on the available scientific understanding of these kinds of impacts. Impact ratings were developed for the key stressors identified in Table 3.6 and following the matrix methodology described in Section 3.3. Acoustic takes for the airgun array, single mitigation gun, the MBES echosounder and the sub-bottom profiler were combined in determining magnitude (one of the components required to determine severity). Three density scenarios were assessed for these acoustic take (termed Base, Upper and Potential), largely as a means to highlight the potential impact of data limitations (including inter-annual variability and methodological assumptions). Matrixes were collapsed where species or groups of species were assessed as having identical determinations (i.e., were consistent for a particular impact rating). Severity and impact assessment methodology aimed to be precautionary, to highlight the repetitive nature of the survey and anticipated responses (avoidance) at close ranges, and draw attention to any identified stressors that exceeded set criteria for a potential population impact. Stressor impact ratings are together reviewed in a species by species substantial adverse effects overview that aims to synthesize data from impact ratings with biologically relevant information, such as capacity to withstand habitat loss (Section 4.5). Where substantial impacts are determined, mitigation methods are proposed to minimize the potential effect (Section 5.0).

4.4.2.1 Impact rating matrices for key stressors

To determine final impact ratings, severity ratings were combined with Likelihood predictions to determine Impact ratings for the population. Impact ratings are ranked from most severe to least**.** Each stressor is defined as acoustic or non-acoustic and partitioned across direct and indirect effects. Information on whether further specific mitigation (MIT) is believed required at a minimum is specified in each matrix. High impact rating is denoted in red and is considered to exceed report criteria for a less than significant population effect.

4.4.2.2 Acoustic impacts of combined active sources (airguns, echosounder and sub-bottom profiler) – Level A

Level A extent was considered local, with moderate duration, intermittent temporal frequency and a high likelihood of occurrence. The reported direct Level A impacts of active acoustic sources used in this survey exceeded negligible (at the population level) for 7 species. High Project impact ratings were determined only for harbor porpoise and at Potential densities for blue and humpback whales using Injury SEL methods. Using NMFS Minimum methods, no candidate species exceeded moderate impact, irrespective of density scenario. All impact ratings resulted from low magnitude take levels (Table 4.10). NMFS Minimum Project impact ratings for harbor porpoise, blue whale and bottlenose dolphins increased under BAR sensitivity analyses. Acoustic impacts of the Project and Alternative 1 to Southern sea otters were considered moderate.

Stressor	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Likelihood
Acoustic Combined	Level A Direct	Local	Tables 4.1-4.3	Moderate	Intermittent	High

Table 4.10 Severity Rating (SR) and final Impact Rating (IR) for Level A (Injury SEL and NMFS Minimum) takes for the proposed Project and Alternatives 1-2. High Impact Ratings are depicted in red and denote potential substantial effects. M denotes medium severity rating based on moderate magnitude level, while M* denotes medium severity rating based on a low magnitude. Empty cells represent negligible ratings.

		Project				Alternative 1				Alternative 2				MIT
	Method	**Injury SEL**		**NMFS Minimum**		**Injury SEL**		**NMFS Minimum**		**Injury SEL**		**NMFS Minimum**		
Species	**Density Scenario**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	
Harbor porpoise	Base	H	**H**	M*	M	H	**H**	M*	M			M*	M	Y
	Upper	H	**H**	M*	M	H	**H**	M*	M	M*	M	M*	M	Y
	Potential	H	**H**	M*	M	H	**H**	M*	M	M*	M	M*	M	Y
Blue whale	Base	M*	M			M*	M			M*	M	M*	M	N
	Upper	M	M	M*	M	M	M	M*	M	M*	M	M*	M	N
	Potential	H	**H**	M*	M	H	**H**	M*	M	M	M	M*	M	Y
Fin whale	Base	M*	M			M*	M							N
	Upper	M*	M			M*	M							N
	Potential	M	M	M*	M	M	M	M*	M	M*	M	M*	M	N
Humpback whale	Base	M*	M			M*	M							N
	Upper	M*	M			M*	M							N
	Potential	H	**H**	M*	M	H	**H**	M*	M	M*	M	M*	M	Y
Bottlenose dolphin	Base			M*	M			M*	M					N
	Upper			M*	M			M*	M					N
	Potential			M*	M			M*	M					N
Risso's dolphin	Base													N
	Upper													N
	Potential			M*	M							M*	M	N
Minke whale	Base													N
	Upper													N
	Potential	M*	M			M*	M							N
Remainder Species	All													N

4.4.2.3 Acoustic impacts of combined active sources (airguns, echosounder and sub-bottom profiler) – Level B

Level B extent was considered regional, with moderate duration, continuous temporal frequency and a high likelihood of occurrence. The reported direct Level B impacts of active acoustic sources used in the Project survey exceeded negligible (at the population level) for 6 species (Table 4.11). Probabilistic Disturbance rms Level B impacts were consistently high across the Project and all Alternatives for harbor porpoise, blue whale, fin whale and humpback whale. NMFS Minimum Level B takes were consistently high across the Project and all Alternatives for harbor porpoise, as well as fin whale and humpback whale under Potential densities. High impact ratings were determined for Alternative 2 only for blue whales at Potential densities and for the Project and Alternatives 1 and 2 for bottlenose dolphins at Upper and Potential densities.

Stressor	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Likelihood
Acoustic Combined	Level B Indirect	Regional	Tables 4.5-4.7	Moderate	Continuous	High

Table 4.11 Severity Rating (SR) and final Impact Rating (IR) for Level B (Probabilistic Disturbance rms and NMFS Minimum) takes for the proposed Project and Alternatives 1-2. High Impact Ratings are depicted in red and denote potential substantial effects. H denotes high severity rating based on high magnitude level, while H* denotes high severity rating based on a moderate magnitude. M* denotes medium severity rating based on a low magnitude. Empty cells represent negligible ratings.

		Project				**Alternative 1**				**Alternative 2**				**MIT**
	Method	**Probabilistic Disturbance rms**		**NMFS Minimum**		**Probabilistic Disturbance rms**		**NMFS Minimum**		**Probabilistic Disturbance rms**		**NMFS Minimum**		
Species	**Density Scenario**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	
Harbor porpoise	Base	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	Y
	Upper	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	Y
	Potential	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	Y
Blue whale	Base	H*	**H**	M*	M	H*	**H**	M*	M	H*	**H**	M*	M	Y
	Upper	H	**H**	M*	M	H	**H**	M*	M	H	**H**	M*	M	Y
	Potential	H	**H**	M*	M	H	**H**	M*	M	H	**H**	H*	**H**	Y
Fin whale	Base	H	**H**	M*	M	H	**H**	M*	M	H	**H**	M*	M	Y
	Upper	H	**H**	M*	M	H	**H**	M*	M	H	**H**	M*	M	Y
	Potential	H	**H**	H*	**H**	H	**H**	H*	**H**	H	**H**	H*	**H**	Y
Humpback whale	Base	H*	**H**	M*	M	H*	**H**	M*	M	H*	**H**	M*	M	Y
	Upper	H	**H**	M*	M	H	**H**	M*	M	H	**H**	M*	M	Y
	Potential	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	Y
Bottlenose Dolphin	Base	M*	M	M*	M	M*	M	M*	M			M*	M	N
	Upper	M*	M	H*	**H**	M*	M	H*	**H**	M	M	H*	**H**	Y
	Potential	M*	M	H	**H**	M*	M	H	**H**	M	M	H*	**H**	Y
Sperm whale	Base													N
	Upper	M*	M	M*	M	M*	M			M*	M	M*	M	N
	Potential	M*	M	M*	M	M*	M	M*	M	M*	M	M*	M	N
Remainder Species	All													N

4.4.2.4 Acoustic impacts of airguns – Secondary prey effects (indirect)

Acoustic effects on fish and invertebrates has the potential to indirectly impact marine mammals through loss of prey resources. The use of seismic air guns during survey operations could disturb or displace adult fish that may occur in the Project area. It is expected that adult fish exposed to seismic sound sources will elicit a behavioral response that will result in either movement away from the approaching sound source (see Appendix I Noise Technical Report), or by hiding within benthic cover (e.g., rocky outcroppings, kelp holdfast structures, or sediment dwellings). Population effects on fish and invertebrates are considered less than significant. Any impacts on marine mammals are likely highest for resident species consuming fish prey (e.g., harbor porpoise and harbor seal).

Species or species group	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Severity Rating	Likelihood	Impact Rating	MIT
Harbor porpoise, harbor seal	Indirect	Local	Moderate	Moderate	Intermittent	Medium	Medium	Moderate	N
Remainder	Indirect	Local	Low	Moderate	Intermittent	Medium	Medium	Moderate	N

4.4.2.5 Acoustic effect of vessel noise – Level B harassment (Indirect)

More than 4,000 large vessels travel along the central California coast every year, most within 15 miles (24 km) of the shoreline of San Luis Obispo County. The majority of them are fishing and recreational vessels that operate out of Morro Bay and to a lesser extent, Port San Luis. Indirect acoustic effects from vessel noise have the potential to affect marine mammals in two ways, either by disturbing their prey or masking their communications. De Robertis and Wilson (2011) present data demonstrating a larger disturbance on fish from a non-quieted oceanographic survey vessel compared to a quieted but comparable vessel. Ship noise is concentrated at frequencies below 1000 Hz and varies with ship design, maintenance and speed (Richardson et al. 1995; Fischer and Brown 2005). Averson and Vendittis (2000) report source levels for a representative 173 m merchant ship that vary from 178 dB re 1μPa at vessel speeds of 8 knots to 192 dB re 1μPa at 16 knots. Given that the R/V Langseth is smaller in size, designed to be quiet for surveys, and will be operating at speeds lower than 8 knots, the source level from the R/V Langseth during this survey is likely to be lower than 178 dB re 1μPa, and thus much lower than the levels produced by the airguns themselves. However the ship will produce sound continuously while underway, whilst the airguns will fire once every ~11 seconds. It is assumed two other smaller vessels will also be operating continuously in the area. Given the frequency overlap between mysticete and vessel noise there may be moderate reductions in effective communication space for these species (Clark et al. 2009). Low magnitude ratings equate to the disturbance of at least one ESA-listed species and hence, fin, humpback and blue whales are ranked at this level. For all other species, this impact is considered negligible (i.e., < 5% of the population).

Species or species group	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Severity Rating	Likelihood	Impact Rating	MIT
Fin, Humpback and Blue whale	Indirect	Local	Low	Moderate	Continuous	Medium	High	Moderate	N
Remainder	Indirect	Local	Negligible	Moderate	Continuous	Negligible	High	Negligible	N

4.4.2.6 Acoustic effect of survey aircraft – Level B harassment (Indirect)

Aircraft can generate significant airborne sound which can be prolonged if surveying a confined area. However, due to the impedance mismatch between air and water, little acoustic energy is transferred across this boundary layer. Most airborne sound that hits the ocean surface at angles >13° from vertical is reflected off the interface back into the air (Richardson et al. 1995). Generally an aircraft must be overhead for the sound to penetrate into the ocean. This limits the amount of sound that enters the water and the duration that sound is present for. The loudest frequency components of aircraft sound are usually below 500 Hz (Richardson et al. 1995). Observations of aircraft impacts on hauled out pinnipeds is mostly anecdotal, but involves increased alertness and potentially a rush into the water. No Elephant seal haul-outs or rookeries exist within the Investigation area, but relatively large California sea lion and harbor seal haul-outs are present in multiple locations. We have assumed survey aircraft will not fly near enough over pinniped haul outs to cause large scale disturbance. Reactions of cetaceans to aircraft over-flight are also mostly anecdotal but can include hasty dives, and other changes in behavior. Response, as per response to purely acoustic stressors, seems to vary depending on behavioral context and location of the individual (Richardson et al. 1995). Due to their ESA status and overlap in frequency between airplane noise and mysticete whale calls, we have listed fin, humpback and blue whales with a higher magnitude for this stressor than all other species. However, given the short duration and isolated temporal frequency of this stressor, the impact rating from this stressor on all species in negligible.

Species or species group	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Severity Rating	Likelihood	Impact Rating	MIT
Fin, Humpback and Blue whale	Indirect	Local	Low	Short	Isolated	Low	Low	Negligible	N
Remainder	Indirect	Local	Negligible	Short	Isolated	Low	Low	Negligible	N

4.4.2.7 Entanglement in airgun or hydrophone strings – Injury/Mortality (direct)

Entanglement in various human made structures can cause injury and death in marine mammals. Porpoises and other small cetaceans suffer from by catch in gillnet fisheries (Tregenza et al. 1997) and mysticete whales also get entangled in lines and other fishing gear (Cassoff et al. 2011). For example, Allen and Angliss (2011) estimate there are at minimum 3.3 gray whale mortalities along the west coast of North America due to entanglement in fishing gear per year. We are not aware of any records of marine mammals being entangled in cables behind a seismic survey vessel. Given that the air-guns and hydrophone cables will be under tension as they are pulled through the water, it is unlikely that a marine mammal would get entangled in the cables even though they extend 6 km behind the vessel. However, given their size fin, humpback and blue whales have been given a slightly higher likelihood of entanglement, and because of their low PBR the magnitude of the effect is also higher than other species. All species nevertheless are deemed to be at low or negligible impact due to entanglement in airgun or hydrophone cables.

Species or species group	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Severity Rating	Likelihood	Impact Rating	MIT
Fin, Humpback and Blue whale	Direct	Local	Low	Moderate	Isolated	Medium	Low	Low	N
Remainder	Direct	Local	Negligible	Moderate	Isolated	Negligible	Very Low	Negligible	N

4.4.2.8 Entanglement in geophone strings – Injury/Mortality (direct)

Cables laid along the sea floor are likely to only pose a risk of entanglement to species diving to the sea floor to forage. Approximately 32 km of geophone cables will be deployed in five different lines running from the shore to offshore locations. Sea otters and harbor seals may come into proximity or contact with the geophone cables during foraging dives, but given their relative size and dexterity it is very unlikely that either species would become entangled in the geophone cable. The only other marine mammal that might potentially forage inshore on the sea floor is the gray whale. In some locations they will forage for benthic amphipods in the substrate on the sea floor (Stelle et al. 2008). This might pose an entanglement risk, however the timing of the survey is such that gray whales will not be present (unless survey is delayed), and should they be present they are in the process of migrating rather than foraging. Thus all species will have a negligible impact from this stressor.

Species or species group	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Severity Rating	Likelihood	Impact Rating	MIT
All	Direct	Local	Negligible	Short	Isolated	Negligible	Very Low	Negligible	N

4.4.2.9 Oil contamination – Injury/Mortality (direct) and Life function effects (indirect)

The likelihood and potential magnitude of oil spills will be reduced by the Oil Spill Contingency plan. The plan states 'All vessels will be USCG-inspected and will have the appropriate spill response equipment onboard' and 'PG&E will maintain an approved oil spill response plan and the appropriate spill response equipment on all vessels. Response drills will be in accordance with federal and state requirements. Contracts with off-site spill response companies will be in-place and will provide additional containment and clean-up resources as needed'. It is unknown whether off-site spill companies are locally based and have the appropriate equipment (like booms) on stand-by. The *R/V Langseth* can carry up to 353,760 gallons of marine gas oil (marine diesel) and has a range of 25,000 km. The vessel will be refueled once during the survey, so there will be two periods when the vessel will be holding near its fuel capacity. At other periods the fuel load will diminish with time. To evaluate the consequences of oil spills on wildlife it is important to understand the properties and chemistry of crude oils and petroleum products. Oil, depending upon its form and chemistry, causes a range of physiological and toxic effects. Volatile components of oil can burn eyes, burn skin, irritate or damage sensitive membranes in the nose, eyes and mouth. Hydrocarbons can trigger pneumonia if it enters lungs. Light hydrocarbons of oil and fuels if inhaled, are transferred rapidly to the bloodstream from the lungs and can damage red blood cells, suppress immune systems, strain the liver, spleen and kidneys and even interfere with the reproductive system. In general, refined petroleum products tend to be more toxic to organisms but less persistent in the environment. Crude oils and heavy fuel oils like bunker fuels tend to be less toxic but are more persistent and more likely to have physical impacts on wildlife e.g., coating fur and skin. Vessels in this study are assumed to carry the latter type. This compositional variation of oil also governs its behavior, weathering and fate after being spilt in the marine environment. Ambient wind and water conditions can modify the impact of oil on wildlife. For example,

on a warmer sea and in high winds, evaporation may remove the lighter aromatic compounds. As a result they do not dissolve into the water column and affect marine life and are therefore not incorporated into the food chain. The discharge of petroleum products may have both direct injury or mortality effects and indirect life function effects (e.g., immuno-suppression). Spill potential effects will also vary across species, with sea otters considered most at risk (due to thermoregulation and direct ingestion/inhalation effects – Garrott et al. 1993). Surface feeding mysticete whales may be more impacted by oil ingestion/mysticete fouling than odontocetes. Pinnipeds can be impacted via toxicity from ingestion (both directly and indirectly if contaminated prey is consumed), thermoregulatory issues if the pelage is covered for fur seals, irritation of membranes especially the eyes and respiratory difficulties (Geraci and St Aubin 1990 cited in PG&E 2011). In terms of magnitude of direct effect, we have placed sea otters in high magnitude given their susceptibility to oil spills and the possibility that >8 animals (>100% of PBR) could be affected. Harbor porpoise are also strongly resident species with low PBR and were also listed as high magnitude. Blue whales are also listed as moderate magnitude given low PBR levels and potential surface feeding behavior increasing exposure. Fin, humpback, minke whales, bottlenose dolphin and Risso's dolphin are listed as low magnitude due to lower relative PBR criteria. The remainder of species were placed in negligible magnitude. Severity ratings were high for sea otters and harbor porpoises and moderate for blue whales. The additional indirect long-term effects of an oil spill are poorly understood for marine mammals. We have placed all species in low magnitude but with low confidence (final row of table below). Given the mainly low speeds of the operational vessels, the assumed quality and diligence of the operational and the contingency plans in place, we have assumed there is a very low likelihood of an oil spill. This results in low or negligible impact ratings from oil contamination.

Species or species group	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Severity Rating	Likelihood	Impact Rating	MIT
Sea otter, Harbor porpoise	Direct	Regional	High	Short	Isolated	High	Very Low	Low	N
Blue whale	Direct	Regional	Moderate	Short	Isolated	Medium	Very Low	Low	N
Fin, Humpback, Minke whale, Bottlenose, Risso's dolphin	Direct	Regional	Low	Short	Isolated	Medium	Very Low	Low	N
Remainder	Direct	Regional	Negligible	Short	Isolated	Negligible	Very Low	Negligible	N
All	Indirect	Regional	Low	Long	Isolated	Medium	Very Low	Low	N

4.4.2.10 Vessel interaction – Injury/Mortality (direct) and non-acoustic disturbance (indirect)

Vessel interaction includes direct impact leading to death or injury to the individual or indirect disturbance caused by the vessel presence. Ships collide with a number of different marine mammals, especially mysticete whales (Laist et al. 2001; Jensen and Silber 2004). It is estimated that 1.2 gray whale and 1 blue whale are killed every year on the west coast of North America from ship strikes with a record of four blue whales reported in 2007 (Allen and Angliss 2011; Carretta et al. 2011). Ships strikes of smaller cetaceans and pinnipeds are much less common, presumably due to their more agile nature. General mitigation strategies are to slow vessel speed (strike leading to mortality or significant injury believed reduced) and to post observers. However, mitigation through reduced speed is not always successful. On October 19, 2009 an oceanographic survey vessel travelling at 5.5 knots approximately 1.3 nautical miles offshore of Fort Bragg California struck and killed a blue whale (http://www.nauticalcharts.noaa.gov/staff/headline-whalestrike.htm). There was not a marine mammal observer during this cruise as one was not required by permits (it was mapping the local bathymetry, not conducting a seismic survey). This is the only known instance of a slow moving oceanographic survey vessel striking a whale. This suggests that this occurrence is unlikely and in suitable daytime conditions can likely be mediated by visual observers. In addition, the noise from the seismic survey is also more likely to cause whales to move away from the survey vessel (e.g., assumed at 90% at 180 dB re: 1 µPa rms), however perhaps not from the chase boat. Vessels will also travel to a from the Investigation area at least 5 times. Blue whales in the study area are known to forage nearer to the surface at night time as they follow the daily vertical migration of krill (Fiedler et al. 1998). We have therefore listed blue whales as having a moderate magnitude from ship strike because of their low PBR and proclivity to spend more time feeding near the surface at night when visual observers will not be able to see them. Likelihood ratings for blue whales were also increased to Medium (possible occurrence) to reflect the increased risk. Fin and humpback whales are listed at low magnitude due to their higher PBR levels than blue whales, but still concern given that mysticete whales are most likely to be struck by ships. The remaining species are listed at negligible magnitude. Therefore, other than blue whales (moderate impact), and fin and humpback whale (low impact), the impact rating is considered negligible.

In terms of indirect non-acoustic effects from vessels, vessel presence can alter the behavior of marine mammals (Lusseau et al. 2009; Williams et al. 2002; Lusseau 2005). For most cetaceans and pinnipeds, the impact from vessel presence is very likely subsumed under the acoustic impacts of the seismic survey. However, given the apparent lack of sensitivity of sea otters to seismic noise, but their known reaction to the presence of vessels (Malme et al. 1984; Udevitz et al. 1995) it is appropriate to consider the impact of vessel presence as a stressor for this species. Based on our estimates of the seismic survey overlap with sea otter densities, less than two otters are likely to be disturbed by the R/V Langseth. However, this number is likely treble that given other support vessel movements. We have assigned sea otters a low magnitude for the seismic survey stressor with a resulting low impact rating. In addition to the seismic survey itself, approximately 32 km of geophone cables will be laid from a vessel off the DCPP. This area has a high density otters, especially near shore. The otter habitat encompassed by these geophone cables is roughly 81 km^2 with an estimate of 173 animals. With a vessel working to deploy and then retrieve these geophones and cables in this area we have listed sea otters as having a moderate magnitude (equivalent of

1.25-2.5% of ESA-listed regional population) for non-acoustic vessel disturbance which leads to a moderate impact rating from this stressor on sea otters. All other species have a negligible magnitude and impact rating.

Species or species group	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Severity Rating	Likelihood	Impact Rating	MIT
Blue whale	Direct	Local	Moderate	Short	Isolated	Medium	Medium	Moderate	Y
Fin and Humpback whale	Direct	Local	Low	Short	Isolated	Low	Low	Low	N
Remainder	Direct	Local	Negligible	Short	Isolated	Negligible	Very Low	Negligible	N
Sea Otter: geophone placement – retrieval	Indirect	Local	Moderate	Short	Isolated	Medium	Medium	Moderate	N
Sea Otter: seismic survey	Indirect	Local	Low	Moderate	Intermittent	Low	Medium	Low	N
Remainder	Indirect	Local	Negligible	Moderate	Intermittent	Negligible	Very Low	Negligible	N

4.5 Impact rating and substantial adverse effects overview.

Marine mammals are wide-ranging, occupying numerous habitats with distinct bathymetric features. Escarpments, characterized by upwelling and vigorous food production, are particularly attractive to many marine mammal species. The Investigation area is considered a productive coastal slope environment, with a local fishing and whale watching industry, and a diverse and often abundant variety of marine mammals. Three species of endangered cetacean (fin, humpback and blue whale) are considered seasonally present with fluctuating temporal abundance, with large concentrations of humpback and blue whales sometimes reported within the Investigation area. Sightings of the endangered sperm whale are considered rare (none reported within the Investigation area, Koski et al. 1998) and extremely remote for both sei and North Pacific right whale. The Investigation area is located between two notable marine mammal hotspots, the Santa Barbara Basin and the Monterrey Canyon system. During the time period of the Project, it is a known migration route for blue, humpback and gray whales (southward predominantly), as well as male and sub-adult California sea lions (northward predominantly). Large schools of many wide-ranging odontocetes (mainly delphinids) can be observed in coastal waters. Two species of pinnipeds (Guadalupe fur seal and Steller sea lion) are considered threatened, but sightings within the Investigation area are considered rare. Resident harbor porpoise (Morro Bay stock), harbor seal and the threatened southern sea otter occur within the Investigation area year-round.

The primary concern of the proposed Project to marine mammals was considered to be the repetitive nature and high source levels of operational noise from the airguns. The contribution of the echosounder and sub-bottom profiler was negligible for low frequency cetaceans (e.g., mysticete), but may increase cumulative SEL-based estimates by ~9% for mid frequency cetaceans, ~19% for high frequency cetaceans (porpoises). The Project may potentially have adverse effects of various types and durations on at least 15 cetacean species, 4 pinnipeds and 1 mustelid using CLSC significance criteria a - level B take using NOAA fisheries thresholds. Based on our simple behavioral avoidance reaction assumptions, Level A harassment (combined active acoustic sources) predicted using the Injury SEL criteria at Base densities was 1-3 individuals of the endangered mysticete species, 23 harbor porpoises (the only species exceeding 100% residual PBR) and 501 California sea lion. At Potential densities, Level A takes exceeded 100% of residual PBR for humpback whales (11 individuals), blue whales (4 individuals) and again harbor porpoise (52 individuals). No species exceeded low magnitude using NMFS Minimum threshold methods (combined active acoustic sources); therefore no high impact ratings were reached for Level A for any candidate species. NMFS Minimum Level A takes of fin (<2), humpback (<3) and blue (<1) whales were low, though exposure was predicted to repeatedly occur up to ~10 times over the course of the survey (based on NMFS Maximum predictions). Level A impact ratings for Alternative 1 were similar, but reduced no high impacts were determined for Alternative 2.

In contrast to Level A takes, high impact ratings from Project Level B takes (combined active acoustic sources) were predicted for the Morro Bay stock of harbor porpoise across all methods, all density scenarios and all Alternatives. Probabilistic Disturbance rms Level B takes of harbor porpoise at Base density amounted to 97% of the minimum population estimate (and 70% of the best population estimate). NMFS Minimum Level B takes amounted to 50% of the minimum population estimate. Thus, using a variety of assessment methodologies and assumptions, the conclusion is that the proposed operations would have a high likelihood of impacting this stock. Similarly, high impact ratings were

consistently determined for all three endangered mysticete whale species using Probabilistic Disturbance rms methodology. In contrast, high impacts were determined for humpback and fin whales using NMFS Minimum only at Potential densities. The California Coastal stock of bottlenose dolphin was also rated at high impact using NMFS Minimum methods at Upper and Potential densities only. The likelihood of these higher density levels occurring for the Coastal stock of Bottlenose dolphins is considered small, unless warm water incursions occur (or after an El Nino event, Koski et al. 1988), nor does this population does not appear to have strong fidelity to any particular area (Carretta et al. 2011).

Acoustic effects on fish and invertebrates have the potential to indirectly impact marine mammals through loss of prey resources. The use of seismic air guns during survey operations could disturb or displace adult fish that may occur in the Project area. It is expected that adult fish exposed to seismic sound sources will elicit a behavioral response that will result in either movement away from the approaching sound source, or by hiding within benthic cover. Population effects on fish and invertebrates are considered less than significant. Impacts on marine mammals are likely highest for resident species consuming fish prey and were determined as moderate.

The Investigation area co-occurs with the core habitat of the increasing Morro Bay Stock of harbor porpoises. Considered resident with limited opportunity for emigration and very sensitive to anthropogenic noise effects, there is a high likelihood of potential for substantial interference in movement and reduction in habitat. Mitigation for Level B harassment to porpoises is unlikely to effective.

The California Current Ecosystem fluctuates both temporally and geographically between September and December, and the timing and location of high density foraging opportunities for mysticete whales are hard to predict, but have in the past occurred within the Investigation area (e.g. 2002). Typical movement by blue and humpback whales northward from Southern California occurs in the mid-summer; with a southward migration then occurring in late fall through November. Transit routes during both periods are likely to co-occur with Investigation area. Noise effects may exceed 200 km downslope (off-shelf) and considerably less coastally. If suitable prey resource concentrations occur within the Investigation area, they are potentially made inaccessible due to noise disturbance or avoidance reactions. In some years, this may result in the loss of a key foraging hotspot (i.e., habitat reduction). The Potential density estimates aim to reflect an increased prey resource concentration within the area, leading to increased predator densities. Given the unpredictability of such an event, a key mitigation method would be to undertake a pre-survey to ensure these conditions were not occurring in an area where the start off the survey was planned.

Overall, with one exception, all non-acoustic stressors were predicted to have low or negligible impacts and non-substantial adverse direct effects, assuming APMs and Contingency plans are fully adopted. Vessel interactions with blue whales were considered a moderate impact based on Medium severity rating and a medium (possible) likelihood rating. Geophone placement and retrieval in the near shore area in front of the DCPP were also considered to result in a moderate impact rating for sea otters due to a medium severity rating and a medium likelihood. Moderate levels of short-term disturbance may also occur to sea otters from the 3D survey, but tracklines and estimated zones of disturbance show only small areas of overlap with high density (shallow water) sea otter areas.

4.5.1 Potential adverse effects summary by species

4.5.1.1 Gray whale

The Investigation Area co-occurs with the migration route for majority of Eastern North Pacific Stock of gray whales, a population numbering up to 19,126. Southward transit through investigation area is estimated to start mid-December (15th) and peaks mid-January (15th). Small numbers may migrate through area prior to predicted start of migration. The majority of population likely to travel within 3 nautical miles of coast and pass through study area in <24 h. with limited feeding expected to take place. Based on likely sensitivity and (somewhat limited) use of low frequency sounds, gray whales may be more likely than odontocete cetaceans to be affected by seismic noise and they have been shown to exhibit localized avoidance to seismic exploration sound (Malme et al. 1984). However, there is no strong evidence suggesting gray whales are particularly sensitive to seismic or other low frequency noises and responses are expected to be limited and temporary avoidance behavior. Assuming survey is completed prior to the middle of December, then project impacts considered insignificant. Impacts of survey scale to the degree of delay beyond December 15th. High and medium magnitude impact considered Level B harassment to 25% (n=4504) and 15% (2703) of minimum population, may occur approximately 23 and 18 days after predicted migration start (January 2-6th), Direct effects up to day 23, including potential Level A takes, highly unlikely to exceed residual PBR of 233 animals, given responses to noise, typically inshore travel patterns and low likelihood of potential entanglement and oil contamination. May affect and may have substantial adverse effects assessment if survey delayed beyond January 2th. *Special mitigation monitoring recommend (initiated only if delayed surveys continue beyond 15th December) to confirm non-blocking avoidance reaction and study prediction of migration transit timing and rate.*

4.5.1.2 Fin whale

Highest density for ESA-listed strategic mysticete species within the Investigation area. Seasonally present from continental slope to offshore, but seasonal movements unclear and assumed lower density in winter. Inter-annual density variability documented (Peterson et al. 2006), reflecting fluctuating prey recruitment and search patterns that appear to concentrate on high density patches. Assumed low frequency hearing sensitivity and selected thresholds of mysticete results in largest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Low predicted numbers of Injury SEL Level A takes (3-9) result in up to moderate (<60% of PBR, non-substantial) direct impact ratings. There are no direct measurements of responses of fin whales to seismic noise, but based on responses in gray and humpback whales localized and temporary avoidance behavior are most likely and may be affected by the behavioral state of animals during exposure. Combined source Probabilistic Disturbance rms takes considered high impact (78-280 individuals), especially in scenarios that reflect increased density above average SERDP-SDSS habitat model predictions (range 3-11% of population affected, of which 40% from using the 120 dB re: 1 µPa rms M-weighted isopleth). In comparison, NMFS Minimum Level A (<2 individuals) and Level B takes (14-60 individuals) were lower. NMFS Level B based Maximum estimates predict individual animals may be exposed up to 34 times over the course of the survey, if animals are assumed not to leave the area. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Lower than average densities (as well as the higher density scenarios modeled here) of fin whale may occur in some years. However, if suitable prey resource concentrations

occur within or near the Investigation area, they are potentially made less accessible or inaccessible due to noise disturbance and/or avoidance reactions for as much as ~2 months. Noise effects on prey may vary between krill and forage fish, but it is assumed that reduced densities of both may occur during and for a short period after the survey. Energetic effort consequently required to locate alternate high value foraging patches, and potentially increase competition for these alternate resources. The project *may affect and may have a substantial adverse effect through habitat modifications/reduction and combined direct and indirect acoustic effects.* Under the assumption that densities of fin whales exceed Upper level densities when the survey is about to start, acoustic effects from seismic operations *likely have a substantial adverse effect through habitat modifications/reduction and combined direct and indirect acoustic effects. Pre-survey assessment of density is considered necessary to provide increased resolution of density and resulting level of potential impact.*

4.5.1.3 Humpback whale

ESA-listed strategic mysticete known to frequent Investigation area, in some years at relatively high densities (September/October, Calambokidis et al. 2002a). Densities considered low by mid-November. Investigation area encompasses known migration route during the survey period, especially southwards movement in late fall. Migration route uses more inshore areas than blue whales, increasing risk of impact. Species known to target both krill and forage fish patches (notably sardine and anchovy) that fluctuate temporally and geographically. Assumed low frequency hearing sensitivity and selected thresholds of mysticete results in largest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Low to moderate predicted numbers of Injury SEL takes (1-11 individuals) result in up to high (<147% of PBR) direct impact ratings. Humpback whales have been demonstrated to have variable responses to seismic noise, including limited local avoidance and, in some cases, attraction to seismic pulses among possible for male individuals (McCauley et al. 1998). Behavioral responses of little to moderate severity may be expected. Combined source Probabilistic Disturbance rms takes considered high impact (37-353 individuals), especially in scenarios that reflect increased density above average SERDP-SDSS habitat model predictions (range 2-19% of population affected, of which 40% from using the 120 dB re: 1 µPa rms M-weighed isopleth). In comparison, NMFS Minimum Level A (<2 individuals) and Level B takes (7-65 individuals) were lower. NMFS Level B based Maximum estimates predict individual animals may be exposed up to 34 times over the course of the survey, if animals are assumed not to leave the area. Non-acoustic effects also rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Local concentrations of humpback whales were observed in September/October 2002, 2006 and 2008. Lower than average density concentrations of humpback whale may also occur in some years. If suitable prey resource concentrations occur within or near the Investigation area, they are potentially made less accessible or inaccessible due to noise disturbance and/or avoidance reactions for as much as ~2 months. Noise effects on prey may vary between krill and forage fish, but it is assumed that reduced densities of both may occur during and for a short period after the survey. Energetic effort consequently required to locate alternate high value foraging patches, and potentially increase competition for these alternate resources. The project *may affect and may have a substantial adverse effect through habitat modifications/reduction and combined direct and indirect acoustic effects.* Under the assumption that densities of humpback whales exceed Upper level densities when the survey is about to start, acoustic effects from seismic operations *likely have a substantial adverse effect through habitat modifications/reduction and combined direct and indirect acoustic effects. Pre-survey assessment of*

density is considered necessary to provide increased resolution of density and resulting level of potential impact.

4.5.1.4 Blue whale

ESA-listed strategic mysticete known to frequent Investigation area, in some years at relatively high densities (September/October, Calambokidis et al 2002a). Investigation area encompasses known migration route during the survey period, especially southwards movement in late fall. Densities considered low by mid-November and decrease from summer peak from September onwards. Species targets mainly krill patches and prefers waters deeper than ~80m locally, with a preference for waters ~200m deep. While concentrations occur mostly in summer, high numbers have also been observed in fall, notably 2000 through 2003. Assumed low frequency hearing sensitivity and selected thresholds of mysticete results in largest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Low predicted numbers of Injury SEL takes (1-4) result in up to high (<190% of PBR) direct impact rating. There are no direct measurements of responses of blue whales to seismic noise, but based on responses in gray and humpback whales localized and temporary avoidance behavior are most likely and may be affected by the behavioral state of animals during exposure. Combined source Probabilistic Disturbance rms takes were considered high impact (38-156 individuals), especially in scenarios that reflect increased density above average SERDP-SDSS habitat model predictions (range 2-8% of population affected, of which 45% from using the 120 dB re: 1 µPa rms M-weighed isopleth). In comparison, NMFS Minimum Level A (<1 individual) and Level B takes (5-20 individuals) were lower. NMFS Level B based Maximum estimates predict individual animals may be exposed up to 29 times over the course of the survey, if animals are assumed not to leave the area. Non-acoustic effects were rated as low to negligible impact (non-substantial), given proposed APMs and Contingency plans, except for vessel interactions which were predicted as moderate impact. Lethal collisions even with slow moving survey boats have occurred in the region recently and risk may increase at night when surface feeding rates increase, from the use of chase boats and during periods when the seismic noise is curtailed and when MMOs are not or less effective. If suitable prey resource concentrations occur within or near the Investigation area, they are potentially made less accessible or inaccessible due to noise disturbance and/or avoidance reactions for as much as ~2 months. Noise effects on krill largely unknown, but it is assumed that reduced densities may occur during and for a short period after the survey. Energetic effort consequently required to locate alternate high value foraging patches, and potentially increase competition for these alternate resources. The project *may affect and may have a substantial adverse effect through habitat modifications/reduction, combined direct and indirect acoustic effects and risk of vessel interactions.* Under the assumption that densities of blue whales exceed Upper level densities when the 3-D survey is started, acoustic effects from seismic operations *likely have a substantial adverse effect through habitat modifications/reduction and combined direct and indirect acoustic effects. Pre-survey assessment of density is considered necessary to provide increased resolution of density and resulting level of potential impact.*

4.5.1.5 Minke whale

Minke whales are considered uncommon in the area but may be occasionally present. Until recently considered a strategic stock, they are found primarily over the continental shelf. Take assumptions have assumed similar behavior and detection rates to blue whales, but animals may be resident to particular home ranges (Koski et al 1998) and are not easily sighted. Assumed low frequency hearing sensitivity

and selected thresholds of mysticete results in largest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. There are no direct measurements of responses of minke whales to seismic noise, but based on responses in gray and humpback whales localized and temporary avoidance behavior are most likely and may be affected by the behavioral state of animals during exposure. Predictions of Injury SEL takes was 0 individual and predictions of combined Probabilistic Disturbance rms takes ranged between 3-10 individuals (1.5-4.8% of population), resulting in negligible impact ratings. In comparison, NMFS Minimum Level A (0 individuals) were similar and Level B takes (<2 individuals) were lower. SERDP-SDSS model predictions considered underestimates based on NOAA unpublished survey data and so takes estimates are likely underestimated. However, population estimates are likely also underestimated and we have assumed takes as a proportion of the population are unlikely to change notably. Furthermore, there is no clear evidence that the Investigation area represent above average habitat to minke whales. Non-acoustic effects also rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. The Project *may affect, but is unlikely to have a substantial adverse effect on minke whales.*

4.5.1.6 Short-beaked common dolphin

Short-beaked common dolphins are the most abundant cetacean in the area and occur from the coast out to at least 500 km offshore, mostly seaward of 200m. Recent population estimates have shown an increase in abundance in California, with large seasonal changes in distribution documented. Occur in large groups (100s or even 1000s), and are likely present in higher numbers in September and October than later in the season (Koski et al 1998). Confirmed multiple occurrences of common dolphins entering safety zone of seismic surveys (Calambokidis et al. 1998). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL Level A takes was up to 28 individuals (<1% of PBR) and predictions of combined Probabilistic Disturbance rms takes ranged between 1047-1997 individuals (0.3-0.6% of population), resulting in negligible impact ratings (non-substantial). NMFS Minimum Level A (37-71 individuals) takes were higher and level B (1012-1931 individuals) takes similar, resulting in negligible impact ratings. All Level A takes may be underestimated if a large school approached the survey vessel. There are no direct measurements of responses of short-beaked common dolphins to seismic noise, but based on responses in other odontocete cetaceans localized and temporary avoidance behavior could occur over some limited range and may be affected by the behavioral state of animals during exposure. Non-acoustic effects also rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Short-beaked common dolphins are very abundant, range widely, with optimal habitat considered seaward of 200m. They are able to prey upon a variety of fish and cephalopod species and consequently considered generalist feeders, with flexible foraging strategy. Good capacity to withstand Level B disturbance. Project *may affect, but is unlikely to have a substantial adverse effect on Short-beaked common dolphins.*

4.5.1.7 Long-beaked common dolphin

Long-beaked common dolphins occur mostly off southern California and Baja California generally within about 90 km of the coast. Occur in large groups (100s), including sightings made within the Investigation area. Confirmed multiple occurrences of common dolphins entering safety zone of seismic surveys

(Calambokidis et al. 1998). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL Level A takes were <2 individual (<2% of PBR) and predictions of combined Probabilistic Disturbance rms takes ranged between 32-117 individuals (0.2-0.7% of population), resulting in negligible impact ratings (non-substantial). Minimum NMFS Level A (1-4) takes were higher and level B (31-113) takes similar, resulting in negligible impact ratings. All Level A takes may be underestimated if a large school approached the survey vessel. There are no direct measurements of responses of long-beaked common dolphins to seismic noise, but based on responses in other odontocete cetaceans localized and temporary avoidance behavior could occur over some limited range and may be affected by the behavioral state of animals during exposure. Non-acoustic effects also rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Long-beaked common dolphins are relatively abundant and range widely. They are able to prey upon a variety of fish and cephalopod species and consequently considered generalist feeders, with flexible foraging strategy. Good capacity to withstand Level B disturbance. Project *may affect, but is unlikely to have a substantial adverse effect on Long-beaked common dolphins.*

4.5.1.8 Small beaked whale species

Due to the rarity of sightings, species of beaked whales in the study area have been grouped. Baird's beaked whales are distributed along continental slopes and throughout deep waters of the North Pacific while Cuvier's beaked whale is the most commonly sighted beaked whale in US West Coast waters (Carretta et al. 2011). Mesoplodont beaked whales are five different species which are distributed along continental slopes and throughout deep waters in the North Pacific Ocean (Koski et al. 1998). Typically seen in small groups. Beaked whales considered to have high sensitivity to anthropogenic sound (Southall et al. 2007, D'AMico et al. 2009, Tyack et al. 2011), are cryptic with long dive times and these factors are reflected in our take estimates. Predictions of Injury SEL Level A takes was 0 individuals, while predictions of Probabilistic Disturbance rms takes ranged between 51-98 individuals (2.0-3.9% of population), resulting in negligible impact ratings (non-substantial). The majority of Probabilistic Disturbance rms take (70%) is based on behavioral disturbance at levels at the 120 dB re: 1 µPa rms M-weighted isopleths, and considered unlikely to cause injurious disruption to diving, as observed in intense mid-frequency sonar exposures. Minimum NMFS Level B takes were considerably lower at <6 individuals. The multiple narrow canyons located ~30 nm south of the Investigation area (off Vandenberg) are considered above average potential habitat for beaked whales, but neither the 140 or 120 dB re: 1 µPa rms isopleths co-occur with this area. While behavioral responses to seismic noise have not been directly measured in beaked whales, based on their apparent sensitivity to sounds of various types, which may be a function of their social and group configurations, there is likely a greater potential for avoidance behavior at greater ranges, even given the low frequency nature of seismic airguns. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the habitat within or near the Investigation area is not considered important to Beaked whales. Project *may affect, but is unlikely to have a substantial adverse effect on Beaked whales.*

4.5.1.9 Harbor porpoise (Morro Bay stock)

The Investigation area co-occurs with the core habitat of the increasing Morro Bay Stock of harbor porpoises. Considered a resident population (best estimate 2044 individuals, minimum 1478 individuals), with very

limited opportunity for emigration, as this stock are not encountered south of Point Conception and the coastal areas north of the Investigation area are considered sub-optimal habitat, with relatively low sighting rates in NOAA surveys. Restricted movement into deeper water (>200m) also unlikely based on strong coastal habitat preferences (mainly <91m water depth). Time period of survey is post the summer calving period and overlaps with the presumed fall breeding season and therefore considered a sensitive period. Species considered very sensitive to anthropogenic noise effects on hearing (Lucke et al. 2009) and on behavior from a wide range of laboratory and field studies (see Southall et al., 2007). Behavioral responses to seismic noise have been infrequently observed in harbor porpoises (Lucke et al. 2009), and based on their apparent sensitivity to seismic noise in this study and also sounds of various types, there is likely a greater potential for avoidance behavior at large ranges, even given the low frequency nature of seismic airguns. Injury SEL takes (23-52 individuals) resulted in up to high direct impact ratings. Level A takes increase dramatically if assumed behavioral avoidance responses to high intensity noise were reduced, but significantly decreased responses are considered unlikely. Both Probabilistic Disturbance rms and NMFS Level B takes were considered high impact, in all 6 scenarios tested (i.e., both methods at all density scenarios). Probabilistic Disturbance rms takes of 1439-3256 individuals equate to 97-100+% of the minimum population estimate. NMFS Minimum Level B takes were lower (734-1662 individuals), but still equate to 50-100+% of the minimum population. A proportion of the Probabilistic Disturbance rms take (30%) were based on behavioral disturbance at the 120 dB re: 1 µPa rms M-weighted isopleths, but habitat avoidance at these intensity levels is predicted to occur. Probabilistic Disturbance rms takes equate to 70-100+% of the best population estimate (NMFS Minimum Level B takes equate to 36-88%). NMFS Level B based Maximum estimates predict individual animals may be exposed up to 26 times over the course of the survey, if animals are assumed not to leave the area. Non-acoustic effects rated as low to negligible and non-substantial, given proposed APMs and Contingency plans. High potential severity rating was noted for oil contamination. The porpoise population is considered at high risk to potential for short-term acoustic-related prey disturbances due to residency. Overall, prediction of substantial interference in movement and reduction in core habitat. A large proportion of the population is likely to be affected. The project *may affect and likely have a substantial adverse effect through habitat modifications/reduction and combined direct and indirect acoustic effects. Mitigation: Impacts to porpoise are believed largely through Level B harassments which are considered very difficult to mitigate given the ranges over which they occur. Sighting and acoustic detections are typically short-range and are unlikely to extend beyond the exclusion zone. Thus even with mitigation measures proposed the Project likely has a substantial adverse effect on harbor porpoise.*

4.5.1.10 Dall's porpoise

Overall density distribution of Dall's porpoise is widespread over the shelf, slope, and deep ocean habitats (mainly >100m). The distribution of Dall's porpoise is highly variable among years/seasons and appears to be affected by oceanographic conditions, however, they are considered to be present locally within the study period. Take estimates have assumed acoustic effect behavior of Dall's porpoise similar to harbor porpoise. Predictions of Injury SEL Level A takes was <2 individuals, while predictions of Probabilistic Disturbance rms takes ranged between 270-568 individuals (0.8-1.8% of population), resulting in negligible impact ratings (non-substantial). The majority of Probabilistic Disturbance rms take (72%) is based on behavioral disturbance at levels using the 120 dB re: 1 µPa rms M-weighted isopleths. Using sensitivity levels of harbor porpoises for Dall's porpoise is considered precautionary. NMFS Minimum level B takes were far lower with 27-56 individuals. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered wide-ranging, flexible in foraging strategy and prefers deep ocean

habitat. Consequently, this species may be considered to have a good capacity to withstand Level B disturbance in one region. Project *may affect, but is unlikely to have a substantial adverse effect on Dall's porpoise.*

4.5.1.11 Pacific white-sided dolphin

Pacific white-sided dolphins are found in cold, temperate waters of the North Pacific Ocean from North America to Asia. They become most abundant in shelf waters off southern California from November to April and then off Oregon and Washington in May. Population may be migrating seasonally from the south to the north in the eastern North Pacific. Generally found in deeper/more offshore water, but can be seen fairly close to shore (Koski et al. 1998). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL Level A takes was <3 individuals, while predictions of Probabilistic Disturbance rms take ranged between 111-212 individuals (0.5-1.0% of population), resulting in negligible impact ratings (non-substantial). NMFS Minimum level A takes were higher (4-8) but still considered negligible magnitude. NMFS Minimum Level B takes and predicted impacts were similar with 107-205 individuals (0.5-1.0% of population). There are no direct measurements of responses of white-sided dolphins to seismic noise, but based on responses in other odontocete cetaceans localized and temporary avoidance behavior could occur over some limited range and may be affected by the behavioral state of animals during exposure. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered wide-ranging, flexible in foraging strategy and prefers deeper habitat. Consequently, this species may be considered to have a good capacity to withstand Level B disturbance in one region. Project *may affect, but is unlikely to have a substantial adverse effect on Pacific white-sided dolphins*

4.5.1.12 Risso's dolphin

The distribution of Risso's dolphin is highly variable, apparently in response to seasonal and interannual oceanographic changes (Forney and Barlow, 1998). Dolphins found off California during colder water months are thought to shift northward into Oregon and Washington as water temperatures increase in late spring and summer. Near-shore year-round species locally and most often sighted cetacean by Padre (2011) with 364 sightings. Feed mainly on squid (Koski et al. 1998). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL Level A takes was <2 individual, while predictions of combined Probabilistic Disturbance rms takes ranged between 48-117 individuals (1.0-2.4% of population), resulting in negligible impact ratings (non-substantial). NMFS level A takes were higher (2-4) but still considered negligible magnitude. NMFS Minimum Level B takes and predicted impacts were similar with 46-113 individuals (0.9-2.3% of population). There are no direct measurements of responses of Risso's dolphins to seismic noise, but based on responses in other odontocete cetaceans localized and temporary avoidance behavior could occur over some limited range and may be affected by the behavioral state of animals during exposure. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered wide-ranging, with a selective foraging strategy. Consequently, this species may be considered to have a moderate to good capacity to

withstand Level B disturbance in one region. Project *may affect, but is unlikely to have a substantial adverse effect on Risso's Dolphin.*

4.5.1.13 Northern right whale dolphin

Species generally considered to occur offshore, but in also regionally seen fairly close to shore, with Padre (2011) reporting 10 sightings. Northern right whale dolphin, Risso's and Pacific white-sided dolphin often seen together in groups. Most groups between 1-300 and feed on squid, lanternfish and mesopelagic fish (Koski et al. 1998). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL Level A takes was <1 individual, while predictions of Probabilistic Disturbance rms takes ranged between 44-79 individuals (0.7-1.3% of population), resulting in negligible impact ratings (non-substantial). NMFS level A takes were higher (1-2) but still considered negligible magnitude. NMFS Minimum Level B takes and predicted impacts were very similar with 36-64 individuals (0.6-1.1% of population). There are no direct measurements of responses of Northern right whale dolphins to seismic noise, but based on responses in other odontocete cetaceans localized and temporary avoidance behavior could occur over some limited range and may be affected by the behavioral state of animals during exposure. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered wide-ranging, and prefers deeper habitat. Consequently, this species may be considered to have a good capacity to withstand Level B disturbance in one region. Project *may affect, but is unlikely to have a substantial adverse effect on Northern right whale dolphin.*

4.5.1.14 Bottlenose dolphin – California coastal stock

The small population of the coastal stock ranges from northern Baja California to Central California. Core habitat mostly off southern California and into Mexican waters, but moves northward into central California during warm-water periods (Carretta et al. 2011). The Investigation area is considered within the northern part of the range. Found largely within 1km of shore (Carretta et al. 1998) and groups of 13+ animals were recorded in the Investigation area (NCCOS 2007). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL takes was 0 individual and NMFS Minimum Level A take was <1 individual, while predictions of Probabilistic Disturbance rms takes ranged between 20-35 individuals (7-12% of the population), resulting in low impact ratings (non-substantial). NMFS Minimum Level B takes were higher with 41-74 individuals (14-26% of population), resulting in low through to high magnitude ratings. There are no direct measurements of responses of bottlenose dolphins to seismic noise, but based on responses in other odontocete cetaceans localized and temporary avoidance behavior could occur over some limited range and may be affected by the behavioral state of animals during exposure. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered to range moderately with a very strong preference for near-shore areas, but the population does not appear to have strong fidelity to any particular area (Carretta et al. 2011). Above Base densities potentially occur only when warm water incursions occur in Central California therefore the Project *may affect, but is unlikely to have a substantial adverse effect on California Coastal bottlenose dolphin.* In the event of a strong El Nino year or a substantial warm water

incursion the Project may have a substantial adverse effect, but this presently appears unlikely (see NOAA Monthly Climate Bulletin for January 2012 at http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/index.shtml).

4.5.1.15 Sperm whale

The sperm whale is the only ESA listed odontocete at sufficient density in the Investigation area to require a take analysis. Population trends are unknown. Sperm whales have been reported year-round off California, with peak numbers appearing from April through mid-June and from the end of August into mid-November. Off California, sperm whales frequent deep offshore waters, although they sometimes venture into shallow water and one group of 6 or more animals was sighted less than 25 nm off Buchon Point (Koski et al. 1998). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL takes was 0 individual and maximum predictions of both level B methods of <2 individuals, resulting in negligible and low impact ratings. Responses of sperm whales to relatively low level seismic noise have been measured (Miller et al. 2009). Results indicate minor changes in foraging behavior in the presence of seismic airguns at moderate ranges, but responses at moderate to higher levels of airgun noise has not been measured. Considering this species' preference for deep offshore water, the chances of it appearing at or near the Investigation area are remote. Non-acoustic effects rated as low to negligible impact and consequently non-substantial. The Investigation area is not considered optimal habitat for sperm whales. Therefore, the Project *may affect, but is not likely to adversely affect, Sperm whales.*

4.5.1.16 Pacific Harbor seal

Pacific Harbor seals are a widely distributed coastal species. They are considered resident to area with foraging typically near shore on fish and cephalopods. Pupping generally occurs March – June and molting generally occurs May – July. Haul-outs with high counts (~50-300 individuals) were recorded in the vicinity of Cayucos Point, Diablo Canyon, Estero Point, China Harbor, Morro Bay Estuary, Fossil Point, South Point, Point San Luis, and Point Buchon. Based on NOAA aerial surveys, total study area population likely >3000 individuals (assuming an at-sea correction factor of 1.65, Lowry et al. 2008). Predictions of Injury SEL Level A takes was 8-15 individuals, while predictions of Probabilistic Disturbance rms takes ranged between 49-95 individuals (0.2-0.4% of stock population), resulting in negligible impact ratings (non-substantial). NMFS Level A and B takes were slightly lower. Comparing level B takes with the local population estimate (based on aerial surveys), ~3% may be disturbed, but repeated Level B exposures of up to 33 times may occur through the survey if animals do not leave the area. Morro Bay lagoon was assumed not to be ensonified above 160 dB re: 1 µPa rms isopleths. Mating courtship will not occur during the proposed time window for the CCCSIP Project and pups will be several months old and somewhat independent of their mothers. There are no direct measurements of the responses of harbor seals to seismic noise, but based on responses in other pinniped, localized and temporary avoidance behavior could occur over limited ranges and may be affected by the behavioral state of animals during exposure. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered abundant and widely distributed, but with the local population that is resident and has a strong preference for near-shore areas. *Project may affect, but not likely to have a substantial adverse effect on Pacific harbor seals.*

4.5.1.17 California sea lion

Large population for US stock with seasonal abundance in central California linked to fall post-breeding typically northward migration of mainly males and sub-adults. Animals typically forage within 20 nmi of shore and was species with maximum number of sightings by Padre (2011). A NOAA aerial survey in September 2008 counted 2,385 animals at 7 locations between Point Sal and San Simeon, with 870 animals counted at Lion Rock, near Point Buchon. Predictions of Injury SEL takes was 501-787 individuals (6-9% of PBR), while predictions of Probabilistic Disturbance rms takes ranged between 3137-4902 individuals (2-3% of population), resulting in negligible impact ratings (non-substantial). Minimum NMFS Level A (110-172 individuals) and Level B (2496-3900) take estimates were lower. Comparing level B takes with the local population estimate, suggest high degree of repeated disturbance to the local population, but overall this population represents just a small fraction of the total stock and thus does not exceed criteria for high impact. Number of individual takes may be higher assuming high turnover rates occur during migration period. Density estimates may also vary due to El Nino. There are no direct measurements of the responses of sea lions to seismic noise, but based on responses in other pinniped, localized and temporary avoidance behavior could occur over limited ranges and may be affected by the behavioral state of animals during exposure. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered very abundant and widely distributed, with very flexible foraging strategy. Considered to have a good capacity to withstand Level B disturbance in one region. *Project may affect, but not likely to have a substantial adverse effect on California sea lion.*

4.5.1.18 Southern sea otter

Southern sea otters range extends from about Half Moon Bay in the north to Santa Barbara in the south. They are resident to the Investigation area where they inhabit the near shore waters, and the highest density within the Point Buchon area. In 2010, the coast from San Simeon to Point Sal contained 874 sea otters, approximately 30.5% of the total stock population. They breed in both June-July and October-November. Invertebrates form majority of diet and typically, dive depths of females <30m and males <40m (USGS 2010). Sea otters appear insensitive to seismic noise (Malme et al. 1984) at ranges >900m, but can be disturbed by close approaches by boats. The NMFS Level A threshold overlaps with sea otter habitat (including in the vicinity of Point Buchon), however, much of the overlap is in waters deeper than 30m (i.e., out of the female and pup core areas). Overall, the overlap area was estimated to contain 61 animals (2.2% of population) and was considered to represent an area of disturbance rather than injury, resulting in a moderate magnitude. Duration of the survey in high density habitat is considered short-term. There is limited available data on responses of sea otters to seismic airguns, as well as their hearing abilities, but the ability to raft without immersing their heads and ears is considered enough to preclude injury. Response may occur to any vessel participating in the survey, particularly during the shooting of near-shore lines. The assessment of disturbance by the survey vessel within 100m estimated 12 individuals may be disturbed. This value could double if the scout boat does not follow a similar route. In addition, the placement and recovery of the geophone lines off Point Buchon is likely to cause additional negative interactions with boats. The entire area encompassing the geophones was estimated to have 173 animals, but only a portion of this total is likely to be disturbed. This vessel disturbance is assumed to be very short term and isolated in placing and removing the lines and overall moderate (non-substantial) impact. Remaining non-acoustic effects rated as low to negligible impact and

consequently non-substantial, given proposed APMs and Contingency plans. Notably, oil contamination of sea otters had a high potential magnitude rating. We have assumed that seismic acoustic effects on the species of invertebrates that sea otters rely upon is negligible. *Project may affect, but not likely to have a substantial adverse effect on sea otters.* Given the scarcity of information with regards to disturbance by seismic surveys on otters, additional mitigation is warranted. Undertaking near-shore surveys in the vicinity of Point Buchon during daylight hours would reduce the likelihood of disturbing large concentrations of animals.

4.6 Potential adverse effects summary for Alternatives.

Alternative 1 excludes Box 3. Reductions in Level A takes amount to 9-12%. Reductions in Level B takes amount to 13-18% (Tables 4.4 and 4.8). Active acoustic source impact ratings however remain near identical compared to the Project. Non-acoustic stressor impact ratings are also considered identical to the Project. No changes are considered warranted in species adverse effects conclusions.

Alternative 2 (Zone 1 and 2) varies significantly from the Project and Alternative 1 in that there are less tracklines in near-shore areas and more in deeper waters (>200m). Alternative 2 has the largest noise footprint, but the distance between tracklines is larger and the total length of trackline is also considerably less, so 'intensity' per area is less than the Project. Reductions in Level A takes amount to >60% for Injury SEL methods, but varied by species using NMFS Minimum methods (increases for deeper water species and large reductions for the coastal species, harbor porpoise, bottlenose dolphins and sea otters, Tables 4.4 and 4.9). Reductions in Level B takes amount to ~8% for Probabilistic Disturbance rms methods, but NMFS Minimum takes saw 10-36% increases for all species, except harbor porpoises (reduced 19%) and Bottlenose dolphins (reduced 21%). NMFS results reflect the increased footprint of Alternative 2 into deeper water (Table 4.8). Non-acoustic stressor impact ratings are considered identical to the Project. No changes are considered warranted in the species adverse effects conclusions.

5.0 Mitigation

Various mitigation strategies can help decrease the impact of the stressors discussed above. Mitigation strategies fall into three general groupings; equipment selection/modification, timing of operations, and distance between operations and animals. Equipment can be improved to reduce impacts on marine mammals; by for example decreasing or better focusing the amplitude of noise the airguns create to image the earth's crust or changing the nature of signals used in imaging geophysical features. While such equipment improvement is a necessary long term goal of the seismic imaging industry, it may be difficult to implement within the time period of a specific project. Rather the best that can be done during a project is to ensure that equipment is well maintained and properly functioning. Using equipment that improves detection of marine mammals can however be successfully implemented during projects. The timing of a survey or timing of activities during the survey can greatly reduce the impacts of various stressors. For example conducting a survey at a time of year when species of concern are not present or at lower densities is one of the most effective mitigation strategies and has been incorporated into the proposed schedule of the Project. Increasing the distance between survey activities and exposed animals can also help decrease the impact of stressors. Generally the more distance between the stressor and the animal, the lower the impact. Thus using larger buffers or avoiding unique areas of concern can help mitigate the impact of stressors, but if those areas are difficult to observe they may lead to a false sense of lesser impact. While the 24/7 survey schedule

reduces the detection rates of MMOs (and consequently may reduce the distance from the stressor) for many of the operational periods, it completes the survey at a faster rate and also does not offer long breaks in operations where animals may return to areas only to be again displaced by operations. Below are mitigation strategies to help mitigate the stressors discussed above.

Mitigation is partitioned into sections related to specific goals.

5.1 Decreasing effects on ESA-listed fin, humpback and blue whales during high densities occurrences
Mysticete whale density can vary a great deal from year to year and are difficult to predict with any confidence. Temporally sporadic high concentrations may occur within the acoustic effect zone of the survey. Our analysis indicates that substantial adverse effects are most likely to occur if high concentrations of mysticetes occur in the Investigation area or the near vicinity. Likelihood of relatively high concentrations occurring were rated as possible, depending on prevailing oceanic conditions. Surveys to assess density should therefore be undertaken prior to the survey and throughout the survey (ideally prior to switching between boxes). It is proposed that consultation with NMFS is undertaken to decide the density threshold for the various mitigation options proposed.

Mitigation 1: Pre-survey of Investigation area and vicinity to 14 km (twice the maximum 160 db rms isopleth) for mysticetes. The survey is best undertaken ~10 days prior to the start of the survey. An intensive multi-day sighting survey is proposed to specifically assess mysticete density and location of any major concentrations.

Options depending on results would be to proceed, selecting the box with the lowest density or to delay the survey until non-critical densities were detected. It is predicted that high concentrations of mysticetes are unlikely to occur for long periods of time (less than 2 weeks) at this time period. Thus reassessment of densities could occur and the survey proceeds later in the season, unless length of resulted survey would result in substantial effects on gray whales (i.e., into January). However, if high concentrations were to remain in the Project area then options include delaying the survey into the following year. This decision would need to be offset with concerns of multi-year stressors then being placed on resident species such as harbor porpoise.

Mitigation 2: Weekly aerial survey of Investigation area and vicinity to 14 km (twice the maximum 160 dB re: 1 µPa rms isopleths) for mysticetes. These surveys aim to ensure no large concentrations of mysticetes are occurring within the larger acoustic effects area or in the next box to be undertaken. High concentrations would lead to survey delays as per Mitigation 1.

Mitigation 3: Adaptive management for the occurrence of multiple shut-downs. More than three shut-downs for mysticete whales results in an immediate project review. Requires real-time data transfer to regulators.

5.2 Decreasing effects on resident species, especially harbor porpoise
Potential effects on harbor porpoise are mainly due to Level B harassment, which are hard to mitigate effectively. Level A harassment of porpoises was considered high magnitude and levels increase if BAR assumptions are lower than predicted.

Mitigation 4: Time the inshore tracks so they coincide with maximum amount of daylight. This potential mitigation option recognizes that many resident species will have high densities in inshore areas (including harbor porpoise, sea otters, bottlenose dolphins and harbor seals). Daylight surveys aim to reduce the likelihood of Level A takes, by increasing detection success by MMOs.

Research recommendation: Aerial surveys are not considered to have sufficient temporal resolution to assess the potential effects of the survey on harbor porpoise. It is proposed that multiple porpoise passive acoustic autonomous click detectors (e.g., Chelonia Ltd. C-PODs) are deployed before, during and after the survey as well as within and outside the Investigation area to assess the effects of the survey on porpoise presence. It is suggested that the design of this study be formulated with the consultation of NMFS. In broad strokes, the study would require three deployments and retrievals of 12+ C-PODS from a small vessel at multiple sites inside and outside of the Project area.

Mitigation 5: Ensure aerial surveys avoid local pinniped haul-outs or occur at high altitude when passing local pinniped haul-outs.

5.3 Decreasing numbers of Level A acoustic takes for all species

A number of strategies exist to reduce the likelihood of Level A acoustic takes and are presented in order of likely effectiveness.

Mitigation 6: Increase the size of the exclusion zone. Realistically, this measure is likely most effective if applied to mysticetes (whose hearing sensitivity overlaps the greatest with seismic airgun signals), Sperm whales and if large groups of marine mammals are observed. Given the maximum 180 dB re: 1 µPa (un-weighted, soft sediment) radius modeled by Jasco Applied Sciences of 856 m, the exclusion zone is likely to be ~1 km. It is proposed that the exclusion zone for large whales and large groups (>20 individuals) of marine mammals be increased to 2 km. MMOs would be able to monitor a 2 km exclusion zone effectively for large whales and large groups of odontocetes, however would not be able to do so for small groups of odontocetes or pinnipeds. Thus the 1 km exclusion zone may be more appropriate for these scenarios.

Mitigation 7: Increase number of scout boats to maximize ability to cover exclusion zone effectively. It is proposed that two scout boats be used with MMOs to increase detection rates within the exclusion zone. These boats would maintain a distance of half the exclusion zone on either side of the survey vessel. During surveying near shore, these scout boats would reorient so as to maintain a minimum of 2 km distance from shore to avoid additional otter disturbance. Additional scout vessels may increase the risk of ship strikes, but this is considered to be more than offset by the additional detections by more dispersed MMOs.

Mitigation 8: Use PAM to localize cetacean detections within or close to the exclusion zone, allowing power-down to occur in poor sighting conditions or at night. Presently, PAM is assumed to be used only to alert MMOs of an acoustic detection.

Mitigation 9: Use of additional equipment and personnel to increase day (big-eye binoculars, additional MMOs, reduction in time of MMOs on shift) and night detection rates (advanced infrared equipment, sodium lighting and millimeter waves radar). There should be a minimum of 3 MMOs per vessel (survey vessel and two scout boats) with 2 MMOs on watch at a time. The third would rest and then rotate with other MMOs to ensure vigilance during watch times.

Mitigation 10: Increase length of pre ramp-up scan period to 45 minutes, especially in poor sighting conditions. Some species have long dive times and only spend short periods of time at the surface between dives. Other species are hard to sight at long range or in poor conditions. Increasing the pre ramp-up scan period increases the chances of sighting these individuals. Similarly, an increase in the time period of exclusion zone observation following power-down or shut-down is proposed.

Mitigation 11: Daylight surveys for production lines near to Church Rock. Church Rock appears to be a hotspot for humpback whales and other cetaceans. Undertaking seismic operations during the daytime in the vicinity of Church Rock would increase chance of detection. Location of Church Rock is N35º 20.675 W120º 59.049. This would affect boxes 2, 3 and 4 since Church Rock is at the confluence of all three of these boxes.

Mitigation 12: Ensure all MMOs are independent and have had considerable experience sighting local species and using PAM.

5.4 Decreasing potential of Level A takes for all species

Mitigation 13: Ensure sufficient 'major' oil spill response equipment for immediate containment is available locally.

Mitigation 14: During transits increase distance to be maintained away from whales to 500m in order to reduce chance of collision.

Special Mitigation 15: The airguns will be shut down if a North Pacific right whale is sighted at any distance from the vessel.

6.0 References

Allen, B. M., & Angliss, R. P. (2011). Alaska Marine Mammal Stock Assessments, 2010. NOAA Technical Memorandum NMFS-AFSC-233: U.S. Department of Commerce.

Angliss, R. P., & Outlaw, R. B. (2007). *Alaska Marine Mammal Stock Assessments , 2006. NOAA Technical Memorandum NMFS-AFSC-168*. *Fisheries (Bethesda)* (p. 1291).

Arveson, P., & Vendittis, D. (2000). Radiated noise characteristics of a modern cargo ship. *The Journal of the Acoustical Society of America*, *107*(1), 118-29.

Au, W. W. L., & Moore, P. W. B. (1990). Critical ratio and critical bandwidth for the Atlantic bottlenose dolphin. *The Journal of the Acoustical Society of America*, *88*(3), 1635-1638.

Bailey, H., Mate, B., Palacios, D., Irvine, L., Bograd, S., & Costa, D. (2010). Behavioural estimation of blue whale movements in the Northeast Pacific from state-space model analysis of satellite tracks. *Endangered Species Research*, *10*, 93-106.

Bain, D. E., & Williams, R. (2006). Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance. *International Whaling Commission Working Paper SC/58/E35*.

Barlow, Jay, Forney, K. A., Hill, P. S., Brownell, R. L., Carretta, J. V., Demaster, D. P., Julian, F., et al. (1997). *U.S. Pacific Marine Mammal Stock Assessments: 1996. NOAA-TM-NMFS-SWFSC-248* (p. 229).

Barlow, Jay, Ferguson, M. C., Becker, E. A., Redfern, J. V., Forney, K. A., Vilchis, I. L., Fielder, P. C., et al. (2009). Predictive modeling of cetacean densities in the eastern Pacific Ocean. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-444: U.S. Department of Commerce.

Benson, Scott R, Croll, D. A., Marinovic, B. B., Chavez, F. P., & Harvey, J. T. (2002). Changes in the cetacean assemblage of a coastal upwelling ecosystem during El Nino 1997 – 98 and La Nina 1999. *Progress in Oceanography*, *54*, 279-291.

Brandt, M. J., Diederichs, A., Betke, K., & Nehls, G. (2011). Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea. *Marine Ecology Progress Series*, *421*, 205–216.

Calambokidis, John, & Osmek, S. D. (1998). *Marine Mammal Research and Mitigation in Conjunction with Air Gun Operation for the USGS "SHIPS" Seismic Surveys in 1998. Final Report* (p. 46).

Calambokidis, John, Schlender, L., & Quan, J. (1998). *Marine Mammal Observations and Mitigation Associated with USGS Seismic Surveys in the Southern California Bight in 1998. Final Report* (p. 14).

Calambokidis, John, & Chandler, T. (2000). *Marine Mammal Observations and Mitigation Associated with USGS Seismic Surveys in the Southern California Bight in 2000. Final Report* (p. 13).

Calambokidis, John, Chandler, T., Schlender, L., Rasmussen, K., & Steiger, G. (2002a). *Research on Humpback and Blue Whales off California, Orgegon and Washington in 2001. Final Report* (p. 50).

Calambokidis, J., Chandler, T., & Douglas, A. (2002b). *Marine mammal observations and mitigation associated with USGS seismic-reflection surveys in the Santa Barbara Channel 2002* (p. 30).

Calambokidis, J., Chandler, T., Schlender, L., Steiger, G. H., & Douglas, A. (2003). *Research on humpback and blue whale off California, Oregon and Washington in 2002: Final Report* (p. 47).

Calambokidis, John, Chandler, T., Faclone, E., & Douglas, A. (2004). *Research on larger whales off California, Oregon, and Washington in 2003, Annual report for 2003 to the Southwest Fisheries Science Center* (p. 48).

Calambokidis, John, Falcone, E. A., Quinn, T. J., Burdin, A. M., Clapham, P. J., Ford, J. K. B., Gabriele, C. M., et al. (2008). *SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final Report* (p. 57).

Calambokidis, John, Falcone, E., Douglas, A., Schlender, L., & Huggins, J. (2009). *Photographic identification of humpback and blue whales off the US West Coast : Results and updated abundance estimates from 2008 field season. Final Contract Report to Southwest Fisheries Science Center* (p. 18).

Carretta, J., Forney, K., & Laake, J. (1998). Abundance of southern California coastal bottlenose dolphins estimated from tandem aerial surveys. *Marine Mammal Science*, *14*(4), 655–675.

Carretta, J.V., Forney, K. A., & Benson, S. R. (2009). Preliminary estimates of harbor porpoise abundance in California waters from 2002 to 2007. NOAA Technical Memorandum, NOAA-TM-NMFSSWFSC-435: U.S. Department of Commerce.

Carretta, James V, Forney, K. A., Oleson, E., Martien, K., Muto, M. M., Lowry, M. S., Barlow, J., et al. (2011). *U.S. Pacific Marine Mammal Stock Assessments: 2010* (p. 357).

Carstensen, J., Henriksen, O., & Teilmann, J. (2006). Impacts of offshore wind farm construction on harbour porpoises: acoustic monitoring of echolocation activity using porpoise detectors (T-PODs). *Marine Ecology Progress Series*, *321*, 295–308.

Cassoff, R., Moore, K., McLellan, W., Barco, S., Rotstein, D., & Moore, M. (2011). Lethal entanglement in baleen whales. *Diseases of Aquatic Organisms*, *96*(3), 175-185.

Clark, Christopher W, & Gagnon, G. C. (2006). Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales. *International Whaling Commission Working Paper SC58/ E9*.

Clark, Christopher W, Ellison, W., Southall, B. L., Hatch, L., Van Parijs, S. M., Frankel, A., & Ponirakis, D. (2009). Acoustic masking in marine ecosystems: intuitions, analysis, and implication. *Marine Ecology Progress Series*, *395*, 201-222.

Cox, T. M., Ragen, T., Read, A., Vos, E., Baird, R., Balcomb, K., Barlow, J., et al. (2006). Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management*, *7*(3), 177–187.

De Robertis, A., & Wilson, C. D. (2011). Silent ships do not always encounter more fish (revisited): comparison of acoustic backscatter from walleye pollock recorded by a noise-reduced and a conventional research vessel in the eastern Bering Sea. *ICES Journal of Marine Science*, *68*(10), 2229-2239.

Di Iorio, L., & Clark, C. W. (2009). Exposure to seismic survey alters blue whale acoustic communication. *Biology Letters*, *6*(3), 334-335.

D'Amico, A., Gisiner, R. C., Ketten, D. R., Hammock, J. a., Johnson, C., Tyack, P. L., & Mead, J. (2009). Beaked Whale Strandings and Naval Exercises. *Aquatic Mammals*, *35*(4), 452-472.

Ellison, W. T., Southall, B. L., Clark, C. W., & Frankel, A. S. (2011). A New Context-Based Approach to Assess Marine Mammal Behavioral Responses to Anthropogenic Sounds. *Conservation Biology*, *26*(1), 21-28.

Erbe, C. (2008). Critical ratios of beluga whales (Delphinapterus leucas) and masked signal duration. *The Journal of the Acoustical Society of America*, *124*(4), 2216-23.

Fernández, A., Edwards, J. F., Rodríguez, F., Espinosa de los Monteros, A., Herráez, P., Castro, P., Jaber, J. R., et al. (2005). "Gas and fat embolic syndrome" involving a mass stranding of beaked whales (family Ziphiidae) exposed to anthropogenic sonar signals. *Veterinary Pathology*, *42*(4), 446-57.

Fiedler, P. C., Reilly, S. B., Hewitt, R. P., Demer, D., Philbrick, V. A., Smith, S., Armstrong, W., et al. (1998). Blue whale habitat and prey in the California Channel Islands. *Deep-Sea Research Part II*, *45*(8-9), 1781–1801. Elsevier.

Finneran, James J., Schlundt, C. E., Dear, R., Carder, D. a., & Ridgway, S. H. (2002). Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *The Journal of the Acoustical Society of America*, *111*(6), 2929.

Finneran, James J, & Schlundt, C. E. (2004). Effects of Intense Pure Tones on the Behavior of Trained Odontocetes. SPAWAR Systems Center Technical Report 1913.

Finneran, James J, Carder, D. a, Schlundt, C. E., & Dear, R. L. (2010a). Temporary threshold shift in a bottlenose dolphin (Tursiops truncatus) exposed to intermittent tones. *The Journal of the Acoustical Society of America*, *127*(5), 3267-72.

Finneran, James J, & Schlundt, C. E. (2010b). Frequency-dependent and longitudinal changes in noise-induced hearing loss in a bottlenose dolphin (Tursiops truncatus). *The Journal of the Acoustical Society of America*, *128*(2), 567-70.

Fischer, R. W., & Brown, N. A. (2005). Factors Affecting the Underwater Noise of Commercial Vessels Operating in Environmentally Sensitive Areas. *OCEANS*, *3*, 1982-1988.

Forney, K. a., & Barlow, J. (1998). Seasonal Patterns in the Abundance and Distribution of California Cetaceans, 1991–1992. *Marine Mammal Science*, *14*(3), 460-489.

Frankel, AS. (2005). Gray whales hear and respond to a 21–25 kHz high-frequency whale-finding sonar. *Proceedings of the16th Biennial Conference on the Biology of Marine Mammals* (pp. 12–16).

Garrott, R. A., Eberhardt, L. L., & Burn, D. M. (1993). Mortality of Sea Otters in Prince William Sound Following the Exxon Valdez Oil Spill. *Marine Mammal Science*, *9*(4), 343-359.

Gedamke, J., Gales, N., & Frydman, S. (2011). Assessing risk of baleen whale hearing loss from seismic surveys: The effect of uncertainty and individual variation. *The Journal of the Acoustical Society of America*, *129*(1), 496-506.

Goold, J. C., & Fish, P. J. (1998). Broadband spectra of seismic survey air-gun emissions, with reference to dolphin auditory thresholds. *The Journal of the Acoustical Society of America*, *103*(4), 2177-84.

Gordon, Jonathan, Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R., & Thompson, D. (2004). A Review of the Effects of Seismic Surveys on Marine Mammals. *Marine Technology Society Journal*, *37*(4), 16-34.

Gotz, T., Hastie, G., Hatch, L., Raustein, O., Southall, B., Tasker, M., Thomsen, F., et al. (2009). Overview of the impacts of anthropogenic underwater sound in the marine environment. OPSAR Commission.

Haley, B., & Koski, W. R. (2004). *Marine Mammal Monitoring During Lamont-Doherty Earth Observatory's ADWBC Seismic Program in the Northwest Atlantic Ocean July - August 2004: LGL Report TA2822-27* (p. 92).

Harris, R. E., Miller, G. W., & Richardson, W. J. (2001). Seal Responses to Airgun Sounds During Summer Seismic Surveys in the Alaskan Beaufort Sea. *Marine Mammal Science*, *17*(4), 795-812.

Hastie, G. D. (2007). Using active sonar to detect marine animals around marine energy devices: behavioural responses by porpoises to sonar signals. SMRU Ltd.

Hastie, G. D., & Janik, V. M. (2007). Using active sonar to detect marine animals around marine energy devices: behavioural responses by grey seals to sonar signals. SMRU Ltd.

Henderson, D., & Hamernik, R. P. (1986). Impulse noise: critical review. *The Journal of the Acoustical Society of America*, *80*(2), 569-84.

High Energy Seismic Survey Team. (1999). High Energy Seismic Survey Review Process and Interim Operational Guidelines for Marine Surveys Offshore Southern California. The California State Lands Commission and The United States Minerals Management Service.

Holst, M., Smultea, M. A., Koski, W. R., & Haley, B. (2005). *Marine Mammal and Sea Turtle Monitoring During Lamont-Doherty Earth Observatory's Marine Seismic Program off the Northern Yucatan Penninsula in the Southern Gulf of Mexico, January - February 2005: LGL Report TA 2822-31* (p. 110).

Holt, M. M., Noren, D. P., Veirs, V., Emmons, C. K., & Veirs, S. (2009). Speaking up: Killer whales (Orcinus orca) increase their call amplitude in response to vessel noise. *The Journal of the Acoustical Society of America*, *125*(1), EL27-32.

Jensen, A. S., & Silber, G. K. (2004). Large whale ship strike database. NOAA Technical Memorandum NMFS-OPR-25: U.S. Department of Commerce.

Jochens, A., Biggs, D., Benoit-Bird, K., Engelhaupt, D., Gordon, J., Hu, C., Jaquet, N., et al. (2008). *Sperm Whale Seismic Study in the Gulf of Mexico: Synthesis Report. OCS Study MMS 2008-006* (p. 341).

Johnson, C. S. (1991). Hearing thresholds for periodic 60-kHz tone pulses in the beluga whale. *The Journal of the Acoustical Society of America*, *89*(6), 2996-3001.

Johnson, C.S., McManus, M., & Skaar, D. (1989). Masked tonal hearing thresholds in the beluga whale. *The Journal of the Acoustical Society of America*, *85*(6), 2651-2654.

Johnston, Dave W. (2002). The effect of acoustic harassment devices on harbour porpoises (Phocoena phocoena) in the Bay of Fundy, Canada. *Biological Conservation*, *108*(1), 113-118.

Kastak, D., Southall, B. L., Schusterman, R. J., & Kastak, C. R. (2005). Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. *The Journal of the Acoustical Society of America*, *118*(5), 3154-3163.

Kastelein, R A, Jennings, N., Verboom, W. C., de Haan, D., & Schooneman, N. M. (2006). Differences in the response of a striped dolphin (Stenella coeruleoalba) and a harbour porpoise (Phocoena phocoena) to an acoustic alarm. *Marine Environmental Research*, *61*(3), 363-78.

Kastelein, Ronald A, Hoek, L., Wensveen, P. J., Terhune, J. M., & de Jong, C. a F. (2010). The effect of signal duration on the underwater hearing thresholds of two harbor seals (Phoca vitulina) for single tonal signals between 0.2 and 40 kHz. *The Journal of the Acoustical Society of America*, *127*(2), 1135-45.

Koski, W. R., Lawson, J. W., Thomson, D. H., & Richardson, W. J. (1998). *Point Mugu Sea Range, marine mammal technical report* (p. 280). King City, Ontario, Canada.

Kremser, U., Klemm, P., & Kötz, W.-D. (2005). Estimating the risk of temporary acoustic threshold shift, caused by hydroacoustic devices, in whales in the Southern Ocean. *Antarctic Science*, *17*(1), 3-10.

Kryter, K. D., Ward, W. D., Miller, J. D., & Eldredge, D. H. (1966). Hazardous exposure to intermittent and steady-state noise. *Journal of the Acoustical Society of America*, *39*(3), 451-464.

Kujawa, S. G., & Liberman, M. C. (2009). Adding insult to injury: cochlear nerve degeneration after “temporary” noise-induced hearing loss. *The Journal of Neuroscience*, *29*(45), 14077-85.

LGL. (2009). *Environmental Assessment of a Marine Geophysical Survey by the R/V Marcus G . Langseth in the Northeast Pacific Ocean , August – September 2009* (p. 218).

Laist, D., Knowlton, A., & Mead, J. (2001). Collisions between ships and whales. *Marine Mammal Science*, *17*(1), 35-75.

Ljungblad, D. K., Moore, S. E., Clarke, J. T., & Bennett, J. C. (1988). Distribution, Abundance, Behavior and Bioacoustics of Endangered Whales in the Western Beaufort and Northeastern Chukchi Seas, 1979-1987. MMS OCS Study MMS-87-0122: U.S. Department of the Interior.

Lowry, M. S., Carretta, J. V., & Forney, K. A. (2008). Pacific Harbor Seal Census in California During May-July 2002 and 2004. *California Fish and Game*, *94*(4), 180-193.

Lucke, Klaus, Siebert, U., Lepper, P. a, & Blanchet, M.-A. (2009). Temporary shift in masked hearing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli. *The Journal of the Acoustical Society of America*, *125*(6), 4060-70.

Lurton, X., & DeRuiter, S. (2011). Sound radiation of seafloor-mapping echosounders in the water column, in relation to the risks posed to marine mammals. *International Hydrographic Review*, (November), 7-17.

Lusseau, D. (2005). Residency pattern of bottlenose dolphins Tursiops spp. in Milford Sound, New Zealand, is related to boat traffic. *Marine Ecology Progress Series*, *295*, 265-272.

Lusseau, David, Bain, D., Williams, R., & Smith, J. (2009). Vessel traffic disrupts the foraging behavior of southern resident killer whales Orcinus orca. *Endangered Species Research*, *6*(3), 211–221.

Madsen, P T, Payne, R., Kristiansen, N. U., Wahlberg, M., Kerr, I., & Møhl, B. (2002). Sperm whale sound production studied with ultrasound time/depth-recording tags. *The Journal of Experimental Biology*, *205*, 1899-906.

Madsen, P. T., Johnson, M., Miller, P. J. O., Aguilar Soto, N., Lynch, J., & Tyack, P. (2006a). Quantitative measures of air-gun pulses recorded on sperm whales (Physeter macrocephalus) using acoustic tags during controlled exposure experiments. *The Journal of the Acoustical Society of America*, *120*(4), 2366.

Madsen, P., Wahlberg, M., Tougaard, J., Lucke, K., & Tyack, P. (2006b). Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. *Marine Ecology Progress Series*, *309*, 279-295.

Malme, C. I., Miles, P. R., Clark, C. W., Tyak, P., & Bird, J. E. (1983). Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior. MMS Report No. 5366: U.S. Department of the Interior.

Malme, C. I., Miles, P. R., Clark, C. W., Tyak, P., & Bird, J. E. (1984). Investigation of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. MMS Report No. 5586: U.S. Department of the Interior.

Manly, B., Moulton, V., Elliott, R., Miller, G., & Richardson, W. (2007). Analysis of covariance of fall migrations of bowhead whales in relation to human activities and environmental factors, Alaskan Beaufort Sea: Phase I, 1996-1998. MMS OCS Study MMS-2005-033: U.S. Department of Commerce.

Mate, B. R., Stafford, K. M., & Ljungblad, D. K. (1994). A change in sperm whale (Physeter macrocephalus) distribution correlated to seismic surveys in the Gulf of Mexico. *Journal of the Acoustical Society of America*, *96*(5), 3268-3269.

McCarthy, E., Moretti, D., Thomas, L., DiMarzio, N., Morrissey, R., Jarvis, S., Ward, J., et al. (2011). Changes in spatial and temporal distribution and vocal behavior of Blainville's beaked whales (Mesoplodon densirostris) during multiship exercises with mid-frequency sonar. *Marine Mammal Science*, *27*(3), E206-E226.

McCauley, R. D., Jenner, M.-N., Jenner, C., McCabe, K. A., & Murdoch, J. (1998). The response of humpback whales (Megaptera novaeangliae) to offshore seismic survey noise: Preliminary results of observations about a working seismic vessel and experimental exposures. *APPEA Journal*, *38*, 692-707.

Miller, P.J.O., Biassoni, N., Samuels, A., & Tyack, P. L. (2000). Whale songs lengthen in response to sonar. *Nature*, *405*(6789), 903.

Miller, G., Moulton, V., Davis, R., Holst, M., Millman, P., MacGillivray, A., & Hannay, D. (2005). Monitoring seismic effects on marine mammals - southeastern Beaufort Sea. 2001-2002. In S. Armsworthy, P. Cranford, & K. Lee (Eds.), *Offshore oil and gas environmental effects monitoring/approaches and technologies.* (pp. 511-542). Columbus, OH: Battelle Press.

Miller, Patrick J O, Johnson, M., Madsen, P. T., Biassoni, N., Quero, M., & Tyack, P. L. (2009). Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. *Deep Sea Research Part I: Oceanographic Research Papers*, *56*(7), 1168-1181.

Mooney, T. A., Nachtigall, P. E., & Vlachos, S. (2009a). Sonar-induced temporary hearing loss in dolphins. *Biology letters*, *5*(4), 565-7.

Mooney, T. A., Nachtigall, P. E., Breese, M., Vlachos, S., & Au, W. W. L. (2009b). Predicting temporary threshold shifts in a bottlenose dolphin (Tursiops truncatus): the effects of noise level and duration. *The Journal of the Acoustical Society of America*, *125*(3), 1816-26.

Moors, H., & Terhune, J. M. (2004). Repetition patterns in Weddell seal (Leptonychotes weddellii) underwater multiple element calls. *The Journal of the Acoustical Society of America*, *116*(2), 1261-1270.

NCCOS. (2007). *A Biogeographic Assessment off North / Central California : In Support of the National Marine Sanctuaries of Cordell Bank , Gulf of the Farallones and Monterey Bay. Phase II - Environmental Settings and Update to Marine Birds and Mammals. Ocean Science* (p. 306). Silver Spring, MD.

National Oceanic and Atmospheric Administration. (2009). Taking and Importing Marine Mammals: U.S. Navy Training in the Hawaii Range Complex; Final Rule. *Federal Register*, *74*(7), 1456-1491.

National Oceanic and Atmospheric Administration. (2009). Taking and Importing Marine Mammals; U.S. Navy's Atlantic Fleet Active Sonar Training (AFAST) Final Rule. *Federal Register*, *74*(16), 4844-4855.

National Research Council. (2005). *Marine mammal populations and ocean noise: Determining when noise causes biologically significant effects* (p. 142). Washington, DC: The National Academies Press.

National Science Foundation. (2011). Environmental Impact Statement/ Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey.

Nowacek, Douglas P., Thorne, L. H., Johnston, D. W., & Tyack, P. L. (2007). Responses of cetaceans to anthropogenic noise. *Mammal Review*, *37*(2), 81-115.

Olesiuk, P. F., Nichol, L. M., Sowden, M. J., & Ford, J. K. B. (2002). Effect of the Sound Generated By an Acoustic Harassment Device on the Relative Abundance and Distribution of Harbor Porpoises (Phocoena phocoena) in Retreat Passage, British Columbia. *Marine Mammal Science*, *18*(4), 843-862.

PG&E. (2011). *Central Coastal California Seismic Imaging Project Permit Application*.

Padre Associates. (2011). *Marine Wildlife Monitoring Report PG&E Geophysical Surveys Offshore Point Buchon for the Survey Period: December 2010 to February 2011* (p. 19).

Parks, Susan E, Clark, C. W., & Tyack, P. L. (2007). Short- and long-term changes in right whale calling behavior: the potential effects of noise on acoustic communication. *The Journal of the Acoustical Society of America*, *122*(6), 3725-31.

Peterson, B., Emmett, R., Goericke, R., Venrick, E., Mantyla, A., Bograd, S. J., Shwing, F. B., et al. (2006). The state of the California Current, 2005 – 2006 : warm in the north, cool in the south. *CalCOFI*, *47*, 30-74.

Richardson, W J, Würsig, B., & Greene Jr, C. R. (1986). Reactions of bowhead whales, Balaena mysticetus, to seismic exploration in the Canadian Beaufort Sea. *The Journal of the Acoustical Society of America*, *79*(4), 1117-28.

Richardson, W John, Wursig, B., & Greene, C. R. (1990). Reactions of Bowhead Whales , Balaena mysticetus, to Drilling and Dredging Noise in the Canadian Beaufort Sea. *Marine Environmental Research*, *29*, 135-160.

Richardson, W. John, Greene Jr, C. R., Malme, C. I., & Thomson, D. H. (1995). *Marine mammals and noise* (p. 576). San Diego: Academic Press.

Richardson, W., Miller, G., & Greene Jr, C. R. (1999). Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. *Journal of the Acoustical Society of America*, *106*(4), 2281.

Rolland, R. M., Parks, S. E., Hunt, K. E., Castellote, M., Corkeron, P. J., Nowacek, D. P., Wasser, S. K., et al. (2012). Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society B: Biological Sciences*.

Romano, T. A., Keogh, M. J., Kelly, C., Feng, P., Berk, L., Schlundt, C. E., Carder, D. A., et al. (2004). Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. *Canadian Journal of Fisheries and Aquatic Sciences*, *61*(7), 1124–1134.

Rugh, D. J., Muto, M. M., & DeMaster, D. P. (1999). Status review of the eastern North Pacific stock of gray whales. NOAA Technical Memorandum NMFS-AFSC-103: U.S. Department of Commerce.

Rugh, D. J., Shelden, K. E. W., & Schulman-Janiger, A. (2001). Timing of the gray whale southbound migration. *Journal of Cetacean Research and Management*, *3*(1), 31–39.

Schlundt, C E, Finneran, J. J., Carder, D. a, & Ridgway, S. H. (2000). Temporary shift in masked hearing thresholds of bottlenose dolphins, Tursiops truncatus, and white whales, Delphinapterus leucas, after exposure to intense tones. *The Journal of the Acoustical Society of America*, *107*(6), 3496-508.

Smultea, M. A., Holst, M., & Koski, W. R. (2004). *Marine Mammal Monitoring During Lamont-Doherty Earth Observatory's Seismic Program in the Southeast Caribbean Sea and Adjacent Atlantic Ocean, April - June 2004: LGL Report TA2822-26* (p. 120).

Southall, Brandon L., Schusterman, R. J., & Kastak, D. (2003). Auditory masking in three pinnipeds: aerial critical ratios and direct critical bandwidth measurements. *The Journal of the Acoustical Society of America*, *114*(3), 1660.

Southall, Brandon L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene Jr, C. R., Kastak, D., et al. (2007). Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals*, *33*(4), 411-521.

Stafford, K. M., Chapp, E., Bohnenstiel, D. R., & Tolstoy, M. (2011). Seasonal detection of three types of "pygmy" blue whale calls in the Indian Ocean. *Marine Mammal Science*, *27*(4), 828-840.

Stelle, L. L., Megill, W. M., & Kinzel, M. R. (2008). Activity budget and diving behavior of gray whales (Eschrichtius robustus) in feeding grounds off coastal British Columbia. *Marine Mammal Science*, *24*(3), 462-478.

Stone, C. J. (2003). The effects of seismic activity on marine mammals in UK waters, 1998-2000. JNCC Report No. 323.

Stone, C., & Tasker, M. (2006). The effects of seismic airguns on cetaceans in UK waters. *Cetacean Research and Management*, *8*(3), 255-263.

Tinker, M. T., Estes, J. A., Ralls, K., Williams, T. M., Jessup, D., & Costa, D. P. (2006). *Population Dynamics and Biology of the California Sea Otter (Enhydra lutris nereis) at the Southern End of its Range: Final Study Report MMS 2006-007* (p. 253).

Tregenza, N., Berrow, S., Hammond, P., & Leaper, R. (1997). Harbour porpoise (Phocoena phocoena L.) by-catch in set gillnets in the Celtic Sea. *ICES Journal of Marine Science*, *54*, 896–904.

Tyack, Peter L, Zimmer, W. M. X., Moretti, D., Southall, B. L., Claridge, D. E., Durban, J. W., Clark, C. W., et al. (2011). Beaked whales respond to simulated and actual navy sonar. *PloS One*, *6*(3), e17009.

U.S. Department of the Navy. (2008). Final Atlantic Fleet Active Sonar Training Range environmental impact statement (EIS)/Overseas environmental impact statement (OEIS), December 2008.

U.S. Geological Survey. (2010). California Sea Otter Survey Data: Spring 2010. Retrieved December 2011, from http://www.werc.usgs.gov/ProjectSubWebPage.aspx?SubWebPageID=4&ProjectID=91

Udevitz, M. S., Bodkin, J. L., & Costa, D. P. (1995). Detection of sea otters in boat-based surveys of Prince William Sound, Alaska. *Marine Mammal Science*, *11*(1), 59–71.

Wade, P., De Robertis, A., Hough, K., Booth, R., Kennedy, A., LeDuc, R., Munger, L., et al. (2011). Rare detections of North Pacific right whales in the Gulf of Alaska, with observations of their potential prey. *Endangered Species Research*, *13*(2), 99-109.

Wartzok, D., & Ketten, D. R. (1999). Marine mammal sensory systems. In R. E. Reynolds & S. A. Rommel (Eds.), *Biology of marine mammals* (pp. 117-175). Washington, DC: Smithsonian Institute Press.

Wartzok, Douglas, Popper, A. N., Gordon, J., & Merrill, J. (2003). Factors Affecting the Responses of Marine Mammals to Acoustic Disturbance. *Marine Technology Society Journal*, *37*(4), 6-15.

Williams, Rob, Trites, A. W., & Bain, D. E. (2002). Behavioural responses of killer whales (Orcinus orca) to whale-watching boats: opportunistic observations and experimental approaches. *Journal of Zoology*, *256*(2), 255–270.

Wright, A. J., & Kuczaj, S. (2007). Noise-related stress and marine mammals: An introduction. *International Journal of Comparative Psychology*, *20*(2-3), III-VIII.

Dear NOAA:

I am writing you today regarding the seismic mapping of Diablo Canyon by PG&E. I am absolutely HORRIFIED that any agency of our legitimate government would consider this..

It is a well-known fact that our sea mammals are intelligent nurturing creatures. It is a well- known fact that these 'BLASTS' from "AIR CANNONS" cause damage and death. PG&E reported on KSBY news that people will have to stay 2 to 3 miles away to prevent injury because seismic blasts could be 'fatal'. They also claimed or bragged that they "HAD BEEN MAPPING ALL OVER THE WORLD AND IT IS PERFECTLY SAFE" . How could this be "perfectly safe" when they just told us everyone had to be 2 to 3 miles away to prevent injury and that these blasts could be fatal? This whole thing stinks. I think they want us far away so we can't count the sea mammal carnage they leave behind. NO NO NO NO NO!

I am also horrified that this would be considered when we are facing severe weather disruption which is and will lead to severe food insecurity. EXACERBATING THIS by killing off 25% of our ocean "mapping" for PG&E's profit IS UNACCEPTABLE. It is also unacceptable that we are killing off mother and calf pairs of whales. This is supposed to be protected sanctuary for their calving activities!

Reports from all over the world of mass whale beachings right before major earthquakes (i.e. Fukishima) have been made leading me and others to wonder if this blasting will not only deafen and destroy our incredible and precious sea-life but possibly CAUSE MAJOR EARTHQUAKES around the world.

I am dismayed that we can visit and explore Mars frequently but we cannot figure out a way to map ocean floors without destroying irreplaceable treasure. This is not an equal trade. We cannot wholesale our Earth's resources just to take a looksee at things. It is NOT OK for anyone to arbitrarily take our natural resources for their profit, and to add insult, charge us to do it and then leave us with a desert where once a rich an abundant ocean existed.

This project is wrong on so many levels, it's hard to know where to begin. But it's easy to know where to stop and that's right here. Let's not let this atrocity go forward another step. . I view this as another failed Cheney Policy; an excuse for corporate welfare for oil. I do not believe for a minute that this "MAPPING" is being done for fault line assessment. I believe it's being done for oil and/or natural gas the drilling of which is to be paid for by the American tax dollar per Cheney's secret Energy Commission which set up the legal framework for this scam. It's one thing to take over our tax dollars, but destroying our environment for purposes of PROFIT? I DO NOT THINK SO. NOT ON MY WATCH. I WANT THIS STOPPED AND STOPPED NOW! NOT ONE WHALE, NOT ONE DOLPHIN. NOT NOW, NOT EVER.!

It is well known and does not need reiteration, but we must treasure our oceans. Without our oceans we cannot exist. So please, help us stop this insanity. We need oceans. We DO NOT NEED MORE OIL nor do we need a nuclear power plant on a major fault line. What were they thinking?

Sincerely

Karen Archer-Hutchison

RECEIVED 09-19-12 PRI

Ms. Kari M. Graton
4465 Sycamore Road
Atascadero CA.93422

Mr. P.Michael Paine
Chief of Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway, Silver Spring, MD

Re: Incidental harassment authorization for Pacific Gas and Electric Co. and the Lamont-Doherty Earth Observatory of Columbia University to conduct sonic testing offshore Central California.

Mr. Paine:

As a lifelong resident of San Luis Obispo County, a former commercial fisherman, an avid boater, outdoors person and a concerned citizen, I am asking you to deny the subject applicant any authorization to harass, take or otherwise disturb any protected species of marine life regulated under the authority of your agency.

As you know, for decades, the unregulated take of marine fish, mammals, birds, crustaceans and countless other marine organisms were the result of many commercialized endeavors. Some of these activities purposefully exploited existing stocks of these organisms as targeted food products. Massive takes of organisms other than the targeted species occurred as take incidental to those efforts. Other activities, such as seismic testing for offshore oil deposits for example, resulted in further incidental take of many marine life resources.

Many years ago, when our nation became acutely aware of the decline of our precious living marine resources, we passed into law certain acts in order to protect those resources from unnecessary exploitation. Your agency has played a large role in ensuring that protection, and we are beginning to recognize some recovery of their populations once again towards healthy, robust levels.

The unavoidable and significant impacts identified in the Environmental Impact Report and the Environmental Assessment filed by this applicant for the subject project are un-acceptable, and in direct contrast to genuine efforts towards any real marine life population building efforts.

The applicant has not effectively explored, exhausted or eliminated alternative methods of collecting geologic data which may be suitable for their project.

10-16-12
PE

Study efforts resulting in marine life take impacts of this magnitude should not be permitted avoidance of the existing marine life protection laws, nor should they be in direct conflict with the intent of The Magnuson-Stevens Fishery Conservation and Management Act, regardless of their stated goal.

It is at best, only speculative to conclude this study will definitively collect any useful geologic data that would results in any changes in design, operation or licensing for the power plant in question, thereby reducing any logic to uphold a statement of overriding concern to the unavoidable significant impacts outlined in the required environmental reports, or for your agency to find merit in their application for an Incidental Harrassment of Marine Mammals.

I urge you to give your upmost attention to this matter, and exercise your authority to protect our vital marine resources and the public trust.

I am, therefore, calling on you to deny the subject permit.

Sincerely,

Kari

Kari Graton

ITP Goldstein <itp.goldstein@noaa.gov>

Comment for P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, 1315 East-West Highway, Silver Spring, MD 20910.

Katie Franklin <katielovesemily@hotmail.com> Wed, Sep 19, 2012 at 11:53 AM
To: itp.goldstein@noaa.gov
Cc: Katie Franklin <katielovesemily@hotmail.com>

P.Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, 1315 East-West Highway, Silver Spring, MD 20910.

Comment for the above listed Chief;

Please do not approve any seismic testing in the Central Coast of California. This is overkill. This is protected and should be honored as protected. Seismic testing should be banned in all oceans for that matter.
We know we are not safe with a Nuke located on the fault(s) on the ocean where tidal waves can hit. We know the waste is not something that can be handled anywhere safely.
It is all unsafe. Seismic testing ads to the problem with devastating effects that are uncalled for and never appropriate. The life under the sea can't talk. But if they could they would surely be irate at the thought!!
Thank you.

Katie Franklin
1613 7th St Los Osos Ca 93402

Howard Goldstein <howard.goldstein@noaa.gov>

No seismic testing!

kelly lewis <onekellylew@gmail.com> Mon, Oct 15, 2012 at 12:57 AM
To: ITP.Goldstein@noaa.gov, Howard.Goldstein@noaa.gov

Protected means just that.
It is unconscionable that you would approve of PG&E's plan for high intensity seismic testing in Estero Bay and MPA's
Approval would expose you as invalid.

Thank you,

Kelly Lewis
2345 Cimarron Way
Los Osos 93402

Kelly Reed Daulton
622 Crocker St.
Templeton, CA 93465

P. Michael Payne, Chief, Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

September 20, 2012

Dear Mr. Payne,

I am aware that seismic testing conducted from Diablo Canyon Nuclear Power Plant will harm and/or kill all marine live within 500 square miles, including within the Point Buchon Marine Reserve. Such destruction is unacceptable.

Because of grave and valid concerns voiced by the fishing and environmental communities, seismic testing must be delayed to allow time to thoroughly explore other technologies less harmful to marine life, and baseline studies of marine life must be completed and analyzed before any testing begins.

Because there is no plan for storing the radioactive wastes for the 250,000 years they will remain lethal; because Homeland Security classifies all nuclear facilities as targets of terrorism; and because of the 13 earthquake faults in the area around Diablo Canyon, I support the concept that the plant be shut down and all stored radioactive waste transferred to hardened casks as soon as possible.

Thank you.

Kelly Reed Daulton

Kelly Reed Daulton

09-25-12
PRI

ITP Goldstein <itp.goldstein@noaa.gov>

please dont kill the sea animals they are our friends and the earth cannot survive without them

kelvin <sinaicrafts@gmail.com> Sun, Oct 14, 2012 at 8:06 PM
Reply-To: sinaicrafts@gmail.com
To: ITP.Goldstein@noaa.gov

Please don't kill the sea animals they are our friends and the earth cannot survive without them.

ITP Goldstein <itp.goldstein@noaa.gov>

Takes of Marine Mammals

Larry Raio <lraio@charter.net> Mon, Oct 1, 2012 at 1:04 PM
To: ITP.Goldstein@noaa.gov

Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California, November to December, 2012

I read most of the "Anticipated Effects on Marine Mammal Habitat" and the proposed mitigation and I have to tell you it was very disturbing to me. First of al, to allow any amount of "take" in a marine protected sanctuary should not even be a consideration. Marine protected areas are set up to achieve the long term conservation of nature with associated ecosystem services and cultural values. The proposed survey does the opposite of that. It is clear that there will be a substantial take from these studies, and in my humble opinion, this is unacceptable.

Larry Raio
1355 16th Street
Los Osos, CA 93402

ITP Goldstein <itp.goldstein@noaa.gov>

OPPOSED to PGE Seismic Testing

LEONARD J BERRY <lbval@sbcglobal.net> Fri, Oct 12, 2012 at 3:47 PM
To: ITP.Goldstein@noaa.gov

Please do not grant the permit to PGE to do this seismic testing. This testing will not make us "safe" from problems at the aging Diablo Canyon Nuclear Plant. PGE has listed a "take" of marine life that is deplorable. I am confident that National Marine Fisheries Service as the agency mandated to protect marine life, including endangered species and marine sanctuaries, is the agency that will deny this. I thank you for your much respected scientific work and for representing the best interests of all of us.

Respectfully,

Leonard Berry

September 20, 2012

Dear Mr. P. Michael Payne and National Marine Fisheries Service,

Concerning the PG&E Sismic Testing off the California Central Coast, your intervention is critical at this time. This offshore seismic test proposal is an ocean genocide and too high a gamble that will likely destroy sustainable marine life along our coast for years at least. More importantly, it has the potential of releasing some seismic reaction as it sends major air blasts across 500 square miles of coastal earthquake zone. (See FRAKing seismic oops's).

Please read the EIR 'kill list' and substantial impact if these tests proceed. I may be a bit exaggerated, but if 180 decibels will kill a human being, please imagine what 190,000 Hiroshima level (243 decibel)l blasts will do to the 500 square mile ecosystem, as they go off every FIFTEEN SECONDS for 30 days non-stop. The sensors will be on chain 'rakes' that crawl the ocean bottom tearing out whatever they hit. Wholesale destruction and imbalance is imminent.

The whales and sharks and dolphins can flee, maybe seals and otters can go ashore but what do the larvae, kelp beds, starfish, and greater non-mammal micro-system do? There is no 'running away' for the ecosystem. 290,000 Hiroshima events at 15 mite intervals. Can you support that cost to the coastal waters and risk that its world is turned into dead floating oil slime across our ocean surface?

We are no safer after these tests. We will have just wasted time and $ resources to do the wrong thing. Sacrifice our marine environment for more info about an aging nuclear plant's safety on top of an acknowledged major earthquake zone?

There are less invasive (magnetic testing) to safely test underwater seismic fault lines pertinent to the Diablo Nuclear facility's exact seismic risk. In reality, there are already enough indicators to suggest and support plant shutdown on the current planned schedule.

A Phase-In of the Diablo energy production alternative option generation possibilities (Solar first) could go far with the $64 Million estimated cost of these destructive and non-productive Seismic Tests.

Please support STOPPING THE OFFSHORE SEISMIC TESTS due to the unacceptable risk and unacceptable long range damage to our marine habitat.

Please allow local hearings about the 6 miles of Morro Bay dune area impact and let us review the mitigation proposed for this offshore oil exploration.

Thankyou,

Linde Owen
1935 10th B
Los Osos, CA 93402
(805) 528-6403

09-25-12
AR1

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

LindieO <seavive@gmail.com>
To: ITP.Goldstein@noaa.gov

Sun, Oct 14, 2012 at 10:14 PM

P. Michael Payne, Chief, Permits and Conservation Division,
Office of Protected Resources, National Marine Fisheries Service.

Dear Sir:

Please do not allow the U.S. Navy to move forward with their proposal to conduct seismic and explosive exercises during the next five years. Too much is at risk. There are studies that have not been considered in the proposal that point to extreme damage to marine life. These important studies that linked seismic surveys to strandings are not mentioned in proposal. Specifically the report by Gentry (2000) called "Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000" is not mentioned, let alone discussed in detail. Report by Malakoff 2002 called "Suit ties whale deaths to research cruise" only mentioned briefly without significant discussion. Other occurrences such as Madagascar stranding are not mentioned at all.

These are documented cases that have not been mentioned in proposal (read more detailed description in our previous **post**):

1. Mozambique 2006,

2. Gulf of California, 2002

3. Galapagos Islands, 2000

4. Madagascar, 2008

5. Peru, 2012

6. Interesting Statistics from Australia (2002-2004)

3. Crucial study that showed cardiorespiratory changes in beluga whale in response to acoustic noise is not even mentioned in proposal (**link**). In this study belugas were exposed to noise at much lower level than is planned in California and the animal demonstrated severe tachycardia "at lower noise intensities (as low as 140 dB);"

4. This proposal is rushed and the levels of impact are not investigated enough and not accessed based on the best scientific evidence available.

5. The company's planned actions lack transparency, they should be required to fully and publicly disclose where activities take place, what equipment will be used, exact Sound Pressure Levels, when activities will take place. Additionally, marine mammal observers logs where they record all marine mammal sightings should be publicly available.

6. The proposal lacks specifics of how strandings will be investigated. It does not include what

protocol of stranding investigation will be, what independent organizations will investigate strandings, who and in what manner will look for the evidence of acoustic trauma, decompression sickness related embolism, hemorrhage, etc.

7. NMFS should deny the permit based on omission of the best scientific evidence available and inadequate assessment of impact on marine life.

Sincerely,

Lindie O'Brien

ITP Goldstein <itp.goldstein@noaa.gov>

NO seismic testing...ever!!!!

The Texs <thetexs@charter.net> Tue, Oct 16, 2012 at 12:18 AM
To: ITP.Goldstein@noaa.gov

I am a member of the general public, living in San Luis Obispo, and I vehemently oppose the proposed seismic testing slated to be conducted in Central Coast waters this fall by PG & E.

I realize that AB 42 (the bill sponsored by San Luis Obispo-based State Senator, Sam Blakeslee, that requires PG & E to conduct seismic testing in our waters) was an attempt by policymakers to look after the safety of the Central Coast residents following the tragedy in Japan last year. But, as Tom Franciskovich, publisher of *SLO Life Magazine*, asks in his article "Seismic Testing" (October-November 2012), "…how do highly detailed three-dimensional maps of the area's spider web of fault lines change anything currently taking place at Diablo Canyon? Eventually, they will produce an earthquake… and there is nothing that can be done to stop it."

But the cost of this testing with dubious information to offer is the probable devastation of the Central Coast's unique and abundant marine life. I read in Franciskovich's article that many in our local fishing industry were at first interested in what they could "get" in terms of compensation from PG & E for damage to sea life in our waters. But now they are more interested in the preservation of that sea life.

I beg you to use your influence to stop this testing debacle from happening.

Sincerely,
Lorna Teixeira

Lorna Teixeira
376 Buena Vista Ave.
San Luis Obispo, CA 93405

ITP Goldstein <itp.goldstein@noaa.gov>

WHY!?!

Luciana Manning <luciana19rj@gmail.com> Sun, Oct 14, 2012 at 8:30 PM
To: ITP.Goldstein@noaa.gov

How long are we going take lives to "save" lives!?

There is no justification for something like that, what about create research about diseases that kill our children instead hurting animals????? Stop harming those poor creatures from the ocean! They are beautiful and they don't cause any harm to us, Humans. If we can still call ourselves that, we are worst than animals, we are monsters and just think about money and power! It's time to rethink what we are doing to this planet. There is no more time for war, save your family and your planet while you can. Don't be Stupid!!!!

Did you ever see the smile on the face of the a little kids that see the dolphins and whales jumping and playing???? Don't take that from them! Let the new generation enjoy the beautiful and natural ritual that only those animals have! I chalenge you, COLD MEAN HUMAN, to take your children to a whale/ dolphin sighting and I want to see if you going to change your mind, if you don't, Kill yourself because you are a heartless piece of crap!

Luciana, BRAZIL!

ITP Goldstein <itp.goldstein@noaa.gov>

Comments for PG&E permit

mandy davis <wildheartcomm@hotmail.com> Mon, Oct 15, 2012 at 1:06 AM
To: "ITP.Goldstein@NOAA.gov" <itp.goldstein@noaa.gov>
Cc: "coastalliance@yahoogroups.com" <coastalliance@yahoogroups.com>, Lucy J Swanson <janeslo@me.com>

To: ITP.Goldstein@NOAA.gov

To: P. Michael Payne, Chief

Permits and Conservation Division

Office of Protected Resources

National Marine Fisheries Service

1315 East-West Highway, Silver Spring, MD 20910

Sent by email c/o ITP.Goldstein@NOAA.gov

Dear Mr. Payne;

In response to the potential issuance of a permit to engage in high intensity acoustic seismic testing off the coast of Central California to PG&E, a coalition called the C.O.A.S.T. Alliance has been formed and motivated to action. Below you will find our mission/position statement.

Mission:

“The C.O.A.S.T. (Citizens Opposing Acoustic Seismic Testing) Alliance, a diverse coalition of individuals, associations and government and non-government organizations is unified in the goal of ending any efforts to permit and undergo high intensity acoustic seismic testing by PG&E in the regions surrounding the Diablo Canyon Power plant on the central coast of California.”

Position Statement:

“In recognition of the significant biological impacts and the resulting negative impacts to our coastal economy, C.O.A.S.T. seeks a cessation to all preparations for offshore acoustic testing now in progress and an end to all plans to engage in high intensity acoustic testing as means for seismic mapping. The Alliance further recognizes that testing new faults is not mandated in AB 1632 and that the only legal mandate is to review and assess existing studies and thereby makes the proposed testing superfluous and not a legal requisite to adhere to the legislation. We insist that the permitting process cease in accordance with the fact that an issuance of the permit would not comply with the Coastal Act, Chapter 3 and would be in violation of the Endangered Species

Act, the Marine Mammal Protection Act, the California MLPA (Marine Life Protection Act), and the Magnusen-Stevens Fisheries Act, as well as several established international marine conservation laws. Further, we insist that the permitting agencies follow the precautionary principle as it relates to biological communities and recognize their responsibility to the human communities involved and to the devastation that the acoustic seismic testing would wreak on the economy of the Central Coast. We understand and agree that mitigation of said impacts by PG&E is an unacceptable option and cannot be construed as a responsible solution to the impacts of high intensity acoustic seismic testing both now and in the future."

You will have no doubt already received three letters addressing specific issues we have with the permitting process. One from Julie Thomas from our Science Committee, one from Hunter Kilpatrick of the Gray Whale Coalition, one of the member groups in our Alliance, and another from Darryl Terra and Brian Stacy of the two local commercial fishing organizations (again key members of the Alliance) addressing commercial fishing issues

They have all brought up key issues as relates to the validity of your issuing an IHA to PG&E. What I would like to bring to your attention in this matter supports their observations and documented data and should be one of your considerations. One of the primary conditions that PG&E is siting will keep their project in compliance is their claim of effective monitoring throughout the process. According to various studies done by reputable research teams, surface monitoring will at best yield a 2% positive identification of mortality and injury in marine animals, inclusive of cetaceans, pinnipeds, mustilids and all fish species. By the time that the negative effects of the testing are observed, necropsies done and action taken, the damage to the marine environment will be done and mitigation measures will be useless and after the fact.

This miniscule percentage of accuracy in a potential surface and air monitoring program is unacceptable and is not a viable condition for issuance of the permit at any time.

We at C.O.A.S.T respectfully ask that you employ the Precautionary Principle as pertains to marine wildlife, admit that there is too much potential for mortality and damaging displacement of marine wildlife, and use extreme discretion when contemplating that you are considering the permitting of an unnecessary and extremely destructive technology with no real mitigative measures.

Thank you for your attention in this matter.

Respectfully; Mandy Davis/C.O.A.S.T. Alliance

ITP Goldstein <itp.goldstein@noaa.gov>

(no subject)

Marilyn Raffaele <MCRaffaele@centurytel.net> Mon, Oct 15, 2012 at 9:40 AM
To: ITP.Goldstein@noaa.gov

Please Please Please. Let us move out of the cave man mentality that sees other life forms as nothing. All life is connected and you have the power to do something about respecting that.
Marilyn Raffaele/Cedar, MI

MARINE MAMMAL COMMISSION

11 October 2012

Mr. P. Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910-3225

Dear Mr. Payne:

The Marine Mammal Commission, in consultation with its Committee of Scientific Advisors on Marine Mammals, has reviewed the application submitted by the Lamont-Doherty Earth Observatory, in cooperation with Pacific Gas and Electric Company (PG&E), seeking authorization under section 101(a)(5)(D) of the Marine Mammal Protection Act to take small numbers of marine mammals by harassment. The taking would be incidental to a marine geophysical survey to be conducted in the vicinity of a nuclear power plant near Morro Bay, California. The Commission also has reviewed the National Marine Fisheries Service's 19 September 2012 notice (77 Fed. Reg. 58256) announcing receipt of the application and proposing to issue the authorization, subject to certain conditions.

RECOMMENDATIONS

The Marine Mammal Commission recommends that the National Marine Fisheries Service—

- require PG&E and the Observatory to re-estimate the proposed exclusion and buffer zones and associated takes of marine mammals for the mitigation airgun using a model that incorporates site-specific information—if the exclusion and buffer zones and numbers of takes are not re-estimated, require them to provide a detailed justification explaining the rationale for basing the exclusion and buffer zones for the mitigation airgun on modeling results based on measurements made in the Gulf of Mexico;
- provide greater assurance that no more than small numbers of each marine mammal species in the area will be taken and that, for each species or stock, the overall impact will be negligible by basing its determinations on (1) the estimated mean number of individuals of each species in the area that may be taken plus some measure of uncertainty for each species or (2) the estimated maximum number of each species in the survey area that may be taken;
- provide a clear justification for concluding that, in this authorization, taking as much as 15 to 26 percent of a species or stock constitutes small numbers and develop a policy that sets forth the criteria for determining what constitutes "small numbers" for the purpose of authorizing incidental takes of marine mammals by working independently or jointly with the Fish and Wildlife Service and Marine Mammal Commission;
- revise its mitigation measures by (1) retaining the requirement for a 15-minute halt to airgun operations if a small odontocete or pinniped enters the exclusion zone but is not observed

4340 East-West Highway • Room 700 • Bethesda, MD 20814-4498 • T: 301.504.0087 • F: 301.504.0099
www.mmc.gov

outside the exclusion zone, (2) requiring a halt to airgun operations based on the maximum dive times when mysticetes or large odontocetes enter the exclusion zone, and (3) eliminating the option to resume airgun operations after 8 minutes if the sound source is moving and the marine mammal has not been observed outside the exclusion zone;

- provide additional justification for its preliminary determination that the proposed vessel-based monitoring program will be sufficient to detect, with a high level of confidence, all marine mammals within or entering the identified exclusion and buffer zones—such justification should (1) identify those species that it believes can be detected with a high degree of confidence using visual monitoring only under the expected environmental conditions, (2) describe detection probability as a function of distance from the vessel, (3) describe changes in detection probability under various sea state and weather conditions and light levels, and (4) explain how close to the vessel marine mammals must be for observers to achieve high nighttime detection rates;
- require PG&E and the Observatory to (1) report the number of marine mammals that were detected acoustically and for which a power-down or shut-down of the airguns was initiated, (2) specify if such animals also were detected visually, (3) compare the results from the two monitoring methods (visual versus acoustic) to help identify their respective strengths and weaknesses, and (4) use that information to improve mitigation and monitoring methods for future authorizations; and
- work with the National Science Foundation to analyze existing data to help determine the effectiveness of ramp-up procedures as a mitigation measure for geophysical surveys.

RATIONALE

PG&E is funding Lamont-Doherty Earth Observatory to conduct a geophysical survey offshore from the Diablo Canyon Power Plant in central California. The company would use the survey results to evaluate earthquake rupture geometries, earthquake displacements, fault interactions, and fault evolution near the power plant. The incidental harassment authorization would be issued to both PG&E and the Observatory for a one-year period. They expect to conduct additional surveys possibly in the next two years to complete the project.

The applicants are planning to conduct the 2012 survey during the period from 15 November to 31 December. The survey would be conducted in waters up to 400 m deep and would involve approximately 1,418 km of tracklines. The Observatory would use the R/V *Marcus G. Langseth* to conduct the survey and would tow a 36-airgun array (nominal source levels 236 to 265 dB re 1 μPa (peak-to-peak)) at 9 m depth. However, at any given time, only 18 airguns would be in operation with a maximum discharge volume of 3,300 in^3—hence, in effect, the Observatory will be using an 18-airgun array. The vessel also would tow four 6-km hydrophone streamers. In addition, the Observatory would deploy up to 90 geophones onshore along a 9-km portion of Morro Strand. The Observatory also would operate a 10.5–13 kHz multibeam echosounder and a 3.5 kHz sub-bottom profiler continuously throughout the survey. In addition, it would use a gravimeter, magnetometer, four other vessels, and a twin-engine aircraft. The additional vessels would serve as platforms for marine mammal monitoring and deployment of equipment, as well as managing vessel traffic around the survey. The aircraft would monitor the survey area before, during, and after the

survey to detect marine mammals in the area, assess their behavior, and identify behavioral changes that might have occurred in response to the survey.

The Service preliminarily has determined that, at most, the proposed activities would result in a temporary modification in the behavior of small numbers of up to 25 species of marine mammals and that any impact on the affected species would be negligible. The Service does not anticipate any take of marine mammals by death or serious injury. It also believes that the potential for temporary or permanent hearing impairment will be at the least practicable level because of the proposed mitigation and monitoring measures. Those measures include monitoring exclusion and buffer zones and using power-down, shut-down, and ramp-up procedures. Night-time operations would be restricted to areas in which marine mammal abundance is considered low. The operators would shutdown the airguns immediately if and when a North Pacific right whale is sighted, regardless of the distance from the *Langseth*. Ramp-up procedures would not be initiated until the right whale has not been seen at any distance for 30 minutes. Although the Commission considers the probability of sighting a right whale to be extremely low, it appreciates the extra caution that would be taken by PG&E and the Observatory to minimize takes of this species by the geophysical survey.

In addition, PG&E and the Observatory have scheduled the survey to avoid the harbor seal and California sea lion pupping and breeding seasons, the peak gray whale migration period, and the peak harbor porpoise calving season. To address concerns regarding impacts to harbor porpoises, PG&E and the Observatory would (1) implement an extended initial ramp-up during the first transect line, (2) ensure that airgun operations begin during daylight hours, (3) conduct in-situ sound measurements to verify and adjust, if necessary, the proposed exclusion and buffer zones, (4) use protected species observers approved by the National Marine Fisheries Service and placed on two vessels (in addition to the *Langseth*) to monitor marine mammals, (5) fund the use of passive acoustic devices (i.e., C-PODS and moored hydrophones) to detect harbor porpoise responses to the survey, and (6) fund agency personnel to monitor the surrounding beaches for evidence of newly stranded marine mammals. They also would fund (1) aerial surveys for large whales before, during (weekly), and after the geophysical survey and (2) the use of additional passive acoustic devices (i.e., HARPs) near the Monterey Bay National Marine Sanctuary to detect large whale responses to the survey. The National Marine Fisheries Service and U.S. Fish and Wildlife Service would conduct aerial monitoring of harbor porpoises, other small cetaceans, and sea otters (the last being covered under a separate authorization issued by the Fish and Wildlife Service).

The Service has proposed an adaptive management approach for this authorization. During the two-month survey period, the Service would evaluate survey effects on a regular basis, amend the survey plan to address issues that might arise, and—if necessary—suspend the survey. The Service could suspend the survey if (1) aerial surveys or acoustic monitoring devices indicate that moderate or large numbers of harbor porpoises leave their core habitat area, (2) harbor porpoises exhibit unusual behavior (e.g., a large, tight group of 50–100 individuals are observed rafting in an unusual area), (3) a mass stranding (i.e., two or more animals strand simultaneously other than female-calf pairs) occurs or animals are observed milling nearshore, (4) two cetaceans in one day, three in one week, or five or more pinnipeds in one week newly strand (dead or alive) in the area, (5)

a single marine mammal strands with evidence of acoustic trauma, or (6) a marine mammal is struck by a vessel participating in the survey.

The Commission commends the Service for proposing to supplement the commonly required mitigation and monitoring measures and proposing to include an adaptive management process as a condition of the authorization. It encourages the Service to require such measures and processes in other proposed incidental harassment authorizations. That being said, the Commission has additional concerns about this proposed authorization.

Uncertainty in exclusion and buffer zones for the mitigation airgun

Exclusion zones define the area in which marine mammals are sufficiently close to a sound source that they may be injured (i.e., taken by Level A harassment) or killed. Buffer zones delineate the area in which marine mammals are close enough to a sound source that they may be disturbed to the extent that they change their natural behavioral patterns (i.e., taken by Level B harassment). Both zones are established based on the generation and propagation of sound from the source and general assumptions about the effects on marine mammals or responses of marine mammals to sounds with varying characteristics (e.g., frequency, impulse versus continuous), the latter being based on limited observations of marine mammal responses under known conditions.

In 2007–2008, the Observatory conducted sound propagation studies using airgun arrays from the R/V *Langseth* (Tolstoy et al. 2009) and used results from those studies to create a model of sound propagation for estimating exclusion and buffer zones. However, that model was based on a particular set of environmental conditions, and variation in such conditions is known to affect the manner in which sound propagates through the ocean. Indeed, Tolstoy et al. (2009) not only noted that results vary with environmental conditions but also used that variation as justification for measuring sound propagation at multiple locations. The National Science Foundation subsequently followed that example in its preparation of a programmatic environmental impact statement for geophysical surveys by modeling sound propagation under various environmental conditions. Furthermore, Tolstoy et al. (2009) acknowledged that sound propagation is not only variable, but also dependent on water depth, bathymetry, and tow depth of the array. The Observatory has acknowledged that its model overestimates actual received sound levels in deep water (>1,000 m) and underestimates actual received sound levels in shallow water (<50 m). The model also does not allow for bottom interactions, which may have substantial effects on sound propagation in shallow and intermediate (up to 400 m) waters. Such shortcomings raise questions about the utility of the model for estimating received sound levels at certain distances and for establishing exclusion and buffer zones.

In preparation for the proposed survey, PG&E and the Observatory used that model to estimate exclusion and buffer zones for the single mitigation airgun. In contrast, it had Greeneridge Science, Inc., use a range-dependent acoustic propagation model and local environmental parameters (i.e., sound speed profiles, bathymetry, and water depth) to establish the exclusion and buffer zones for the 18-airgun array. On numerous occasions the Commission has recommended that the Service or the Observatory estimate exclusion and buffer zones using either empirical measurements made at the survey site or model predictions based on environmental parameters

from the proposed survey site. The Commission acknowledges that such a model was used for the 18-airgun array and that the Service proposed to require PG&E and the Observatory to conduct in-situ sound studies to verify those zones. However, the Commission is unsure why the applicants used a model derived from Gulf of Mexico data for the mitigation airgun rather than a model based on site-specific parameters as was done for the 18-airgun array. To address this shortcoming, the Marine Mammal Commission recommends that the National Marine Fisheries Service require PG&E and the Observatory to re-estimate the proposed exclusion and buffer zones and associated takes of marine mammals for the mitigation airgun using a model that incorporates site-specific information. If the exclusion and buffer zones and numbers of takes are not re-estimated, the Marine Mammal Commission recommends that the Service require PG&E and the Observatory to provide a detailed justification explaining the rationale for basing the exclusion and buffer zones for the mitigation airgun on modeling results based on measurements made in the Gulf of Mexico.

Uncertainty in take estimates

The Service requires take estimates in each application for an incidental harassment authorization. The estimates provide a basis for ensuring that the proposed activity will not have more than a negligible impact on the affected species or stocks and that only small numbers of marine mammals are taken. Take estimates are often, if not generally, associated with considerable uncertainty. If, for any given species or stock, the error in the take estimate is relatively symmetrical, then a small numbers or negligible impact determination that is based on the expected (e.g., mean) abundance or density without accounting for uncertainty serves the purpose of the Marine Mammal Protection Act about one-half of the time. That is, if the estimated take is an unbiased indicator of the actual take and the error around that expected value is symmetrical, then the actual number of takes will be greater than the expected number about half the time and less than the expected number half the time. If the Service makes its small numbers or negligible impact determinations based on the expected number of takes but does not account for the associated uncertainty, then its assurance of a negligible impact affecting only small numbers of animals is sufficient for the purpose of the Act about 50 percent of the time.

For the proposed survey, PG&E and the Observatory estimated the expected numbers of takes using the size of the buffer zone (and associated ensonified areas) and estimates of marine mammal densities from previous marine mammal and geophysical surveys. The density data were obtained in the same area and during the same season as proposed for the survey. However, the applicants did not account for any specific uncertainty (i.e., standard deviation, standard error, coefficient of variation) in those densities. Instead, they simply increased their take estimates by 25 percent to account for survey lines that may need to be surveyed twice, equipment testing, and repeated exposures of individual animals. The Observatory should account for equipment testing, the possibility of exposing individuals repeatedly, and the need to resurvey certain areas, but doing so is not the same as accounting for uncertainty in the density estimates.

Although PG&E and the Observatory estimated minimum, maximum, and mean densities for the majority of the species that may be taken, they used only the mean densities to estimate expected takes. The Service appears to have done the same. Neither the applicants nor the Service appears to have given due consideration to the error around the take estimates. If, for example, the

Observatory and the Service expect 1,000 takes to occur, the judgment as to whether that level of taking is negligible could depend heavily on whether the uncertainty in that number was small (e.g., ± 5 takes) or large (e.g., ± 500 takes). Furthermore, both the estimated number of takes and the error associated with that estimate should reflect the behavior of the species and stocks that may be taken (e.g., do they form large social, foraging, or reproductive groups, or vary their habitat use patterns by season). To address this concern, the Marine Mammal Commission recommends that the National Marine Fisheries Service provide greater assurance that no more than small numbers of each marine mammal species in the area will be taken and that, for each species or stock, the overall impact will be negligible by basing its determinations on (1) the estimated mean number of individuals of each species in the area that may be taken plus some measure of uncertainty for each species or (2) the estimated maximum number of each species in the survey area that may be taken.

Small numbers and negligible impact determinations for harbor porpoises

The Service originally indicated that up to 59 percent of the individuals in the Morro Bay harbor porpoise stock could be taken incidental to the proposed survey. It increased that estimate to 74 percent after accounting for the possibility of surveying some track lines twice, testing equipment, and repeatedly exposing individual animals. Those percentages were based on the mean take estimate and the best abundance estimate (N_{best}) for the stock and would have been greater—perhaps substantially so—if the Service had based them on a maximum take estimate (or something akin to a maximum estimate, such as the 95th percentile), minimum abundance estimate (N_{min}), or both. But regardless of how they were estimated, they raise the important question of how the Service can best determine whether the number of porpoises that might be taken during the course of the survey and associated activities constitutes "small numbers," as required under the Marine Mammal Protection Act.

Through communications with the Service, the Commission has learned that the applicants have decided to limit their efforts to one of two survey boxes that they were going to survey in 2012. By doing so, they have effectively reduced the expected number of takes to something on the order of 15 to 26 percent of the stock's abundance, depending on the take and abundance values used. Clearly, this is a substantial decrease in the number of takes and the expected portion of the stock to be taken. Still, it is not clear that 15 to 26 percent of a stock constitutes small numbers. Defining what constitutes small numbers is undoubtedly a difficult task, particularly in view of the distinction drawn by the court that "small numbers" and "negligible impact" are not the same thing and the former cannot be defined on the basis of the latter—that is, they are separate standards.

The Commission recognizes that defining "small numbers" is difficult and that there may not be a readily available solution that would apply to the wide variety of marine mammal stocks managed by the Service. Perhaps the best approach to resolve the issue would be for the Service to develop a clear working definition of "small numbers," provide that definition to the public for review and comment, and then adopt a final definition (as modified on the basis of public comments) by regulation or in a policy directive. An alternative would be for the National Marine Fisheries Service, Fish and Wildlife Service, and Commission to form a task force to develop an appropriate working definition that could then be submitted for public review and comment. Until such a definition is developed, the Service will need to provide a justification for its judgments

regarding "small numbers" of marine mammal species taken by various human activities. With that need in mind, the Marine Mammal Commission recommends that, to the best of its ability, the National Marine Fisheries Service provide a clear justification for concluding that, in this authorization, taking as much as 15 to 26 percent of a species or stock constitutes small numbers. Because defining "negligible impact" also is warranted and the suggested approaches for defining "negligible impact" would be similar to those for defining "small numbers," the Commission further recommends that the Service, working independently or jointly with the Fish and Wildlife Service and Marine Mammal Commission, develop a policy that sets forth the criteria for determining what constitutes "small numbers" and "negligible impact" for the purposes of authorizing incidental takes of marine mammals.

Mitigation and monitoring measures

The *Federal Register* notice stated that PG&E and the Observatory would monitor the area near the survey vessel for at least 30 minutes prior to the initiation of, during, and for 30 minutes after cessation of airgun operations. The notice also stated that when airguns have been powered down because a marine mammal has been detected near or within a proposed exclusion zone, airgun activity would not resume until the marine mammal is outside the exclusion zone (i.e., the animal is observed to have left the exclusion zone or has not been seen or otherwise detected within the exclusion zone for 15 minutes in the case of small odontocetes and pinnipeds and 30 minutes in the case of mysticetes and large odontocetes, including sperm, pygmy sperm, dwarf sperm, and beaked whales) or the vessel has transited beyond the original 180-dB re 1 μPa exclusion zone after an 8-minute period.

The Commission has recommended a pause time of at least 15 minutes for small odontocetes and pinnipeds because their dive times are shorter and generally fall within that limit. However, it does not believe that 30 minutes is sufficient for some mysticetes and large odontocetes because they may remain submerged for periods far exceeding 30 minutes. Blainville's beaked whales dive to considerable depths (> 1,400 m) and can remain submerged for nearly an hour (Baird et al. 2006, Tyack et al. 2006). In addition, observers may not detect marine mammals each time they return to the surface, especially cryptic species such as beaked whales and kogiids, which are difficult to detect even under ideal conditions. Barlow (1999) found that "[a]ccounting for both submerged animals and animals that are otherwise missed by the observers in excellent survey conditions, only 23 percent of Cuvier's beaked whales and 45 percent of *Mesoplodon* beaked whales are estimated to be seen on ship surveys if they are located directly on the survey trackline." Thus, at least for certain species, visual monitoring alone is not adequate to detect all marine mammals within the exclusion and buffer zones.

However, the proposed 8-minute pause for transiting vessels effectively eliminates the need for airgun interruptions of 15 and 30 minutes in most instances because the sound source is expected to be constantly moving when the survey is being conducted. The rationale for the pause appears to be that the vessel (or sound source) has moved and therefore has traveled outside the boundary of the exclusion zone where it was when the animal was first sighted. This approach fails to take into account the fact that the animal also may be moving. In fact, the animal's position often is not known because it spends much of its time under the surface where it is not visible and it may

not be sighted when it does come to the surface. Depending on the speed and heading of the vessel and the speed and heading of the marine mammal, the latter clearly may remain in the exclusion zone and may be exposed to dangerous sound levels when airgun operations resume. In short, the Service's rationale for allowing resumption of the airguns after 8 minutes appears to be based on the assumption that the animal is either not moving or is moving in a direction different from that of the ship. Although that assumption may be correct in some cases, it just as easily may be wrong and may put the animal at unnecessary risk. For example, Miller et al. (2009) observed that no sperm whale changed direction to avoid seismic activity at distances of 1–13 km from the vessel, and most whales continued to travel on a course parallel to the sound source. Therefore, unless the marine mammal is sighted leaving or outside the exclusion zone, it does not make sense to resume airgun operations after a shorter period of time based on an unsupported assumption that observed animals would be clear of the exclusion zone after 8 minutes have elapsed.

In addition, the Service indicated that it would not require implementation of ramp-up procedures for the full array after an extended power down because those procedures (1) would not meaningfully increase the effectiveness of observing marine mammals approaching or entering the exclusion zone and (2) would not reduce the potential for take. Again, the Commission disagrees with the Service's reasoning. The primary purpose of ramp-up procedures is not to increase the observer effectiveness, but rather to alert any marine mammals in the area and give them an opportunity to move away from the airgun array before its impulsive sound may harm them. If they do so, then—in fact—ramp-up procedures would reduce the potential for injurious take, which is its intended purpose.

To address these concerns, the Marine Mammal Commission recommends that the National Marine Fisheries Service revise its mitigation measures by (1) retaining the requirement for a 15-minute halt to airgun operations if a small odontocete or pinniped enters the exclusion zone but is not observed outside the exclusion zone, (2) requiring a halt to airgun operations based on the maximum dive times when mysticetes or large odontocetes enter the exclusion zone, and (3) eliminating the option to resume airgun operations after 8 minutes if the sound source is moving and the marine mammal has not been observed outside the exclusion zone. The Commission would welcome a meeting to discuss how best to determine maximum dive times of various marine mammal species using the best available science.

In addition, as discussed in the Commission's previous letters commenting on similar activities by this and other applicants, visual monitoring is not effective during periods of bad weather or at night, especially when the radius of the exclusion zone is approximately 1 km. Although the *Federal Register* notice indicated that multiple vessels would be used for monitoring and that, on average, observers can monitor to the horizon (i.e., 10 km), it is unclear how PG&E and the Observatory expect to see cryptic species (i.e., harbor porpoises and beaked whales) and smaller pinnipeds (i.e., harbor seals) at those distances even in good weather during daylight hours. Aerial surveys would be conducted to supplement vessel-based monitoring, but it appears that those surveys would occur only on a weekly basis. Furthermore, PG&E and the Observatory used Barlow et al. (2009) as the basis for the majority of the density estimates. Those data yielded effective strip widths ranging from 0.78–4.61 km depending on the species. Those distances are much less than PG&E and the Observatory's assumed sighting distance of 10 km. Therefore, the Marine Mammal

Commission recommends that, prior to issuing the requested authorization, the National Marine Fisheries Service provide additional justification for its preliminary determination that the proposed vessel-based monitoring program will be sufficient to detect, with a high level of confidence, all marine mammals within or entering the identified exclusion and buffer zones. At a minimum, such justification should (1) identify those species that it believes can be detected with a high degree of confidence using visual monitoring only under the expected environmental conditions, (2) describe detection probability as a function of distance from the vessel, (3) describe changes in detection probability under various sea state and weather conditions and light levels, and (4) explain how close to the vessel marine mammals must be for observers to achieve high nighttime detection rates. If such information is not available, the Service and the applicant should conduct the studies needed to describe the efficacy of existing monitoring methods and develop alternative or supplemental methods to address current shortcomings.

The *Federal Register* notice also stated that the applicant would conduct vessel-based passive acoustic monitoring to augment visual monitoring during daytime operations and at night to help detect, locate, and identify marine mammals that may be present. The Commission supports the use of passive acoustic monitoring for this purpose but also considers it important to keep in mind the limitations of such monitoring. As the Commission has noted in previous correspondence, and as the Service acknowledges, passive acoustic monitoring is effective only when marine mammals are vocalizing constantly or often and it is less effective when they are vocalizing irregularly or only occasionally. In addition, the effectiveness of passive acoustic monitoring will depend on the operator's ability to locate a vocalizing marine mammal and determine whether it is within the power-down or shut-down radius or in a position such that the ship's movement will place it within the power-down or shut-down radius. To shed light on these concerns, the Marine Mammal Commission recommends that the National Marine Fisheries Service require PG&E and the Observatory to (1) report the number of marine mammals that were detected acoustically and for which a power-down or shut-down of the airguns was initiated, (2) specify if such animals also were detected visually, (3) compare the results from the two monitoring methods (visual versus acoustic) to help identify their respective strengths and weaknesses, and (4) use that information to improve mitigation and monitoring methods for future authorizations.

Effectiveness of ramp-up procedures

Although the effectiveness of ramp-up procedures has yet to be verified empirically, the Service would continue to require PG&E and the Observatory to monitor, document, and report observations during all ramp-up procedures. Such data will provide a stronger scientific basis for determining the effectiveness of, and deciding when to implement, this particular mitigation measure. The National Science Foundation has indicated that monitoring data from past surveys are being compiled into a single database. The Commission supports that effort by the Foundation. After the data are compiled and quality control measures have been completed, the Marine Mammal Commission recommends that the National Marine Fisheries Service work with the National Science Foundation to analyze those data to help determine the effectiveness of ramp-up procedures as a mitigation measure for geophysical surveys. International researchers also are trying to determine the impacts of seismic airguns and the effectiveness of ramp-up procedures, primarily on humpback whales, during specific life history stages. However, the results of those studies are not

yet available and even when they become so, their applicability to other species may be limited. In the interim, the Commission continues to believe that the Service should continue to require data collection and analysis to assess the effectiveness of ramp-up procedures, given that those procedures are considered a substantial component of the mitigation measures.

Please contact me if you have questions about the Commission's recommendations or rationale.

Sincerely,

Timothy J. Ragen, Ph.D.
Executive Director

Cc: Jana Affonso, U.S. Fish and Wildlife Service, Region 8 Ecological Services
Lilian Carswell, U.S. Fish and Wildlife Service, Southern Sea Otter Recovery and Marine Conservation Coordinator

References

Baird, R.W., D.L. Webster, D.J. McSweeney, A.D. Ligon, G.S. Schorr, and J. Barlow. 2006. Diving behavior and ecology of Cuvier's (*Ziphius cavirostris*) and Blainville's (*Mesoplodon densirostris*) beaked whales in Hawaii. Canadian Journal of Zoology 84(8):1120–1128.

Barlow, J., M.C. Ferguson, E.A. Becker, J.V. Redfern, K.A. Forney, I.L. Vilchis, P.C. Fiedler, T. Gerrodette, and L.T. Ballance. 2009. Predictive modeling of marine mammal density from existing survey data and model validation using upcoming surveys. National Oceanic and Atmospheric Administration Technical Memorandum. NOAA-TMNMFS-SWFSC-444. 229 pages.

Barlow, J. 1999. Trackline detection probability for long-diving whales. Pages 209–221 *in* G.W. Garner, S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson (eds.), Marine Mammal Survey and Assessment Methods. Balkema, Rotterdam, The Netherlands.

Miller, P.J.O., M.P. Johnson, P.T. Madsen, N. Biassoni, and P.L. Tyack. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. Deep-Sea Research I 56(7):1168–1181.

Tolstoy, M., J. Diebold, L. Doermann, S. Nooner, S.C. Webb, D.R. Bohenstiehl, T.J. Crone, and R.C. Holmes. 2009. Broadband calibration of R/V *Marcus G. Langseth* four-string seismic sources. Geochemistry, Geophysics, Geosystems 10, Q08011, doi:10.1029/2009GC002451.

Tyack, P.L., M. Johnson, N. Aguilar Soto, A. Sturlese, and P.T. Madsen. 2006. Extreme diving of beaked whales. Journal of Experimental Biology 209(21):4238–4253.

ITP Goldstein <itp.goldstein@noaa.gov>

Diablo Canyon Seismic Imaging Tests

kate chase <chakase@gmail.com> Sat, Oct 13, 2012 at 1:21 AM
To: ITP.Goldstein@noaa.gov

Dear Sirs,

Our families are long time residents of the Central Coast and are very concerned that the PG&E's proposed seismic imaging testing will be extremely harmful to the health of the marine life of the area,
there is no requirement to actually change the safety structure of the Diablo Canyon Power Plant,
this testing will violate the Endangered Species Act by harassing the whales with noise to make them move away, and deafen them which will cause them a slow and lingering death.
it will violate both the Marine Mammal Protection Act and the Magnuson-Stevens Fishery Conservation and Management Act,
the local fishing industry which has finally redeveloped relatively decent fish stocks will be severely damaged which will have tremendous effect to the local economy,
PG&E plans to pass the cost of testing on to ratepayers.

We can't believe this proposal has not already been thrown out.

Please do NOT allow this testing to take place.

Thank you,

Martha Chase
Katherine Chase
Paso Robles

ITP Goldstein <itp.goldstein@noaa.gov>

(no subject)

Martin & Patty Wright <mpbwright3@att.net> Thu, Oct 11, 2012 at 7:56 PM
To: ITP.Goldstein@noaa.gov

Please stop the PG&E underwater seismic testing along the Central Coast.

Thank You,

Patty

ITP Goldstein <itp.goldstein@noaa.gov>

PGE Central Coast Seismic Testing for Diablo Nuclear Waste Plant

Mary E. Webb <maryewebb@charter.net> Thu, Oct 11, 2012 at 3:00 PM
To: ITP.Goldstein@noaa.gov, Director@dfg.ca.gov
Cc: cteufel@coastal.ca.gov, Jennifer.DeLeon@slc.ca.gov, BOta@dfg.ca.gov, hesmith@nsf.gov, cummings@ldeo.columbia.edu, Monica.DeAngelis@noaa.gov, Lilian_Carswell@fws.gov, DBarker@hearstcastle.com, mgleason@tnc.org

Michael Payne, Chief Permits and Conservation Division
Office of Protected Resources, NOAA Fisheries
1315 East West Highway
Silver Spring, MD 20910

RE: Takes of Marine Mammals Incidental to Specified Activities;

Marine Geophysical Survey off the Central Coast of California,

November to December, 2012

Good morning Mr. Payne,

Attached please find Greenspace-the Cambria Land Trust comments on the PGE Seismic Survey project for the Central Coast of California. Greenspace cannot support a permit at this time due to unmitigatable harmful impacts to protected marine resources and species. We request that all permitting agencies hold this project to the highest standards of review in order to protect areas in and around the Monterey Bay National Marine Sanctuary, the Cambria State Marine Park, White Rock Cambria State Marine Conservation Area, Pt. Buchon State Marine Reserve, Pt. Buchon State Marine Conservation Area and the Channel Islands National Marine Sanctuary.

Sincerely,

Mary Webb VP

Greenspace-the Cambria Land Trust

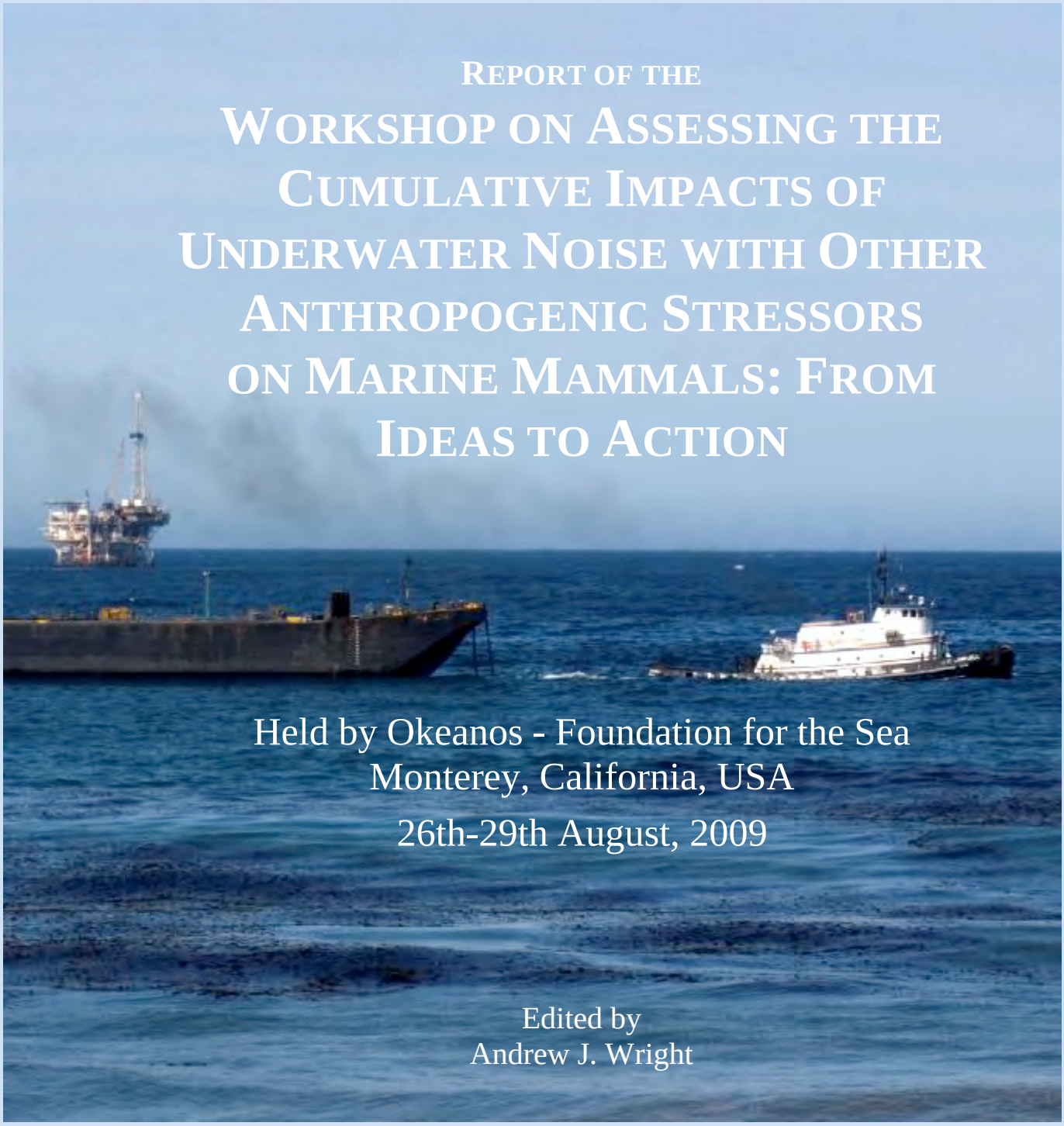
4 attachments

Greenspace Letter Seismic Testing.pdf
93K

Monterey Airgun Alt. Tech. Workshop Report.pdf
671K

CCC_CommentsSeismicSurveys.pdf
282K

OKEANOS. Wright (ed). 2009. Cumulative impacts noise..pdf
2482K



REPORT OF THE

WORKSHOP ON ASSESSING THE CUMULATIVE IMPACTS OF UNDERWATER NOISE WITH OTHER ANTHROPOGENIC STRESSORS ON MARINE MAMMALS: FROM IDEAS TO ACTION

Held by Okeanos - Foundation for the Sea
Monterey, California, USA

26th-29th August, 2009

Edited by
Andrew J. Wright

December, 2009

okeanos - Stiftung für das Meer
Auf der Marienhöhe 15
D-64297 Darmstadt
Telefon +49- 6151-918 20 23
Telefax +49- 6151-918 20 19
mail@okeanos-stiftung.org
www.okeanos-stiftung.org

Wright, A.J. (ed) 2009. Report of the Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals: From Ideas to Action. Monterey, California, USA, 26th-29th August, 2009. Okeanos - Foundation for the Sea, Auf der Marienhöhe 15, D-64297 Darmstadt. 67+iv p. Available from http://www.sound-in-the-sea.org/download/CIA2009_en.pdf

Cover photo courtesy of the Michael H Smith, project coordinator, Gray Whales Count; 211 W Gutierrez St., Studio 8, Santa Barbara, CA 93101. USA. http://www.graywhalescount.org/

Contents

Prologue	iii
7th October 2009 Letter to President Obama	1
24th November 2009 Letter the Interagency Ocean Policy Task Force	3
Mapping Cumulative Threats to Cetaceans from Ocean Noise and Other Stressors	9
Modeling the Population Effects of Cumulative Impacts	19
A Model of Cumulative Impacts on an Individual Marine Mammal	27
Participants	31
Workshop Presentation with Abstracts	33

okeanos - Stiftung für das Meer
Auf der Marienhöhe 15
D-64297 Darmstadt

Telefon +49- 6151-918 20 23
Telefax +49- 6151-918 20 19
mail@okeanos-stiftung.org
www.okeanos-stiftung.org

Prologue

By Dieter Paulmann

As part of our ongoing work on the impacts of anthropogenic (human-made) noise on marine mammals, Okeanos – Stiftung für das Meer (Foundation for the Sea), has held a number of international, multi-disciplinary workshops to investigate and address various aspects of the issue. These workshops have produced discussions that have been both ground-breaking and bridge-building. Scientists from a diversity of disciplines (ranging from biologists to engineers) and policy makers have reached out to each other and advanced not only the science, but established valuable connections and also expanded the range of possible management mechanisms available to address underwater noise.

One important theme to emerge over the course of these workshops is that noise does not act in a vacuum. It affects species that are already facing a variety of other anthropogenic pressures, including contaminants, fisheries and, of course, climate change. Noise can also interact with these stressors in ways that may endanger them further. Appropriate management of cumulative stressors has been lacking partly because many legal systems act on a project-by-project basis. By the same token, scientists are only just beginning to investigate how stressors interact to affect individuals and ultimately populations. The issue is complicated further with respect to the management of cumulative impacts in marine mammal populations as data for these inaccessible animals are limited in any case.

Seeking to find a route forward to more appropriate and comprehensive management techniques for assessing cumulative impacts of noise and other stressors in marine mammals, Okeanos held another workshop in Monterey, California, from 26-29 August, 2009, to investigate the possibilities. Participants were carefully selected from disciplines as diverse as bioacoustics, management practice and network theory, and focus was placed upon free-flowing discussions, as this has proven highly successful in previous meetings. Specifically, participants were asked to consider three approaches to the problem: how currently available tools for regionally mapping anthropogenic pressures on the environment could be applied to the management of species; how the reported consequences of exposure to these pressures in marine mammals and their known interactions on an individual could be modelled; and how population modelling could best include cumulative impact assessment. Promisingly, participants felt that the three approaches could all be fulfilled in at least two data-rich populations – southern resident killer whales and North Atlantic right whales – and that the examples produced by this effort could then be used to inform management decisions for less-studied species, perhaps based on information about exposure to noise and other stressors alone.

What follows is a report of these discussions, in an unconventional form. The participants of the workshop felt that they had a unique opportunity to contribute their combined expertise through timely comments to the new U.S. Interagency Ocean Policy Task Force[1] and by offering suggestions on marine spatial planning, one of the options under discussion that could substantially advance the management of cumulative impacts. The Task Force is, at time of writing, working to construct a new National Policy for the Oceans, Coasts, and the Great Lakes.

[1] On June 12, 2009, President Obama sent a memorandum to the heads of executive departments and federal agencies establishing an Interagency Ocean Policy Task Force, led by the White House Council on Environmental Quality. The Task Force is charged with developing a recommendation for a national policy that ensures protection, maintenance, and restoration of oceans, our coasts and the Great Lakes.

To that end, participants drafted three documents, each addressing one of the three approaches that were explored at the workshop. The first document investigates options for incorporating noise in currently ongoing efforts to map the extent of human impact on the oceans. The second paper considers the possibilities for modelling how these various impacts may act upon populations of marine mammals in combination. The last document describes the potential for modelling how the multiple stressors might act in combination cumulatively, synergistically and antagonistically within an individual.

These background documents were used in support of two letters, also signed by many of the participants. The first was a letter to President Obama (the Task Force were sent a copy) calling for the inclusion of undersea noise in the new National Oceans Policy, while broadly supporting the initiative. It noted that reducing sources of underwater noise can quickly improve the matter as it dissipates relatively quickly, unlike contaminants that will persist in the environment for some time. The letter also pointed out that many measures to substantially address the problem of underwater noise are available now, and that moving forward with these option would provide marine life the best chance at surviving less tractable threats, such as climate change. The second letter was sent to the Task Force directly and summarised the plan developed at the workshop for moving towards a more comprehensive assessment of cumulative impacts. The three discussion papers included in this report were attached to this letter.

To allow wide dissemination of the information contained within these documents, they are written in simple language to the extent possible. It is hoped that, although they are particularly adapted to the current process within the U.S., they will be of interest to a wide, international audience. Similarly, many caveats and much of the fine detail often found in the wider literature have also been left out. These documents should thus be seen as an introduction to the issue of cumulative impacts of noise with other stressors on marine mammals, as well as an exploration of potential solutions. It is hoped that these discussions and recommendations will provide interested parties a firm starting point upon which they can build their knowledge.

In addition to the letters and discussion papers, this report also includes lists of participants and their presentations, the latter with abstracts.

Dieter Paulmann
Founder, Okeanos - Stiftung für das Meer (Foundation for the Sea)
Auf der Marienhöhe 15, D-64297 Darmstadt, Germany.
www.okeanos-stiftung.org

7th October 2009 Letter to President Obama

Participants of the Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals: From Ideas to Action
c/o Okeanos - Stiftung für das Meer / Foundation for the Sea (Workshop Sponsor)
Auf der Marienhöhe 15
D-64297 Darmstadt, Germany

mail@okeanos-stiftung.org

7th October, 2009

President Barack Obama
The White House
1600 Pennsylvania Avenue NW
Washington, DC 20500

Dear President Obama:

We write to urge you to address anthropogenic ocean noise, a growing threat to whales and other marine life, in your new National Oceans Policy.

We applaud the recognition of the threats facing ocean health detailed in your June 12th Presidential Memorandum and welcome your initiative to develop timely strategies to halt and reverse damage to the marine environment. One threat not highlighted, and one we believe is largely curable, is the rising level of noise in the sea, which amplifies the problems already faced by ocean life.

The ocean is a world of sound. Animals such as whales, dolphins, and fish depend on hearing for communicating, foraging, finding mates, detecting predators, and maintaining family and social groups. Human activity is rapidly altering the ocean's natural acoustic habitats. Industrial and commercial underwater noise propagates over enormous distances, affecting millions of square miles of ocean. For example, background noise at the same low frequencies vital to many marine species has increased 100-fold in some locations over the last 50 years. This growing fog of noise is shrinking the perceptual world of whales and other marine life, undermining their ability to "see" with sound. Chronic noise exposure is a recently recognized, largely hidden threat that can reduce long-term survival rates, while exposure to loud noise can result in injury, and even death in certain circumstances. Today few places in the world's oceans remain free of noises from human activities.

An international, multi-disciplinary group of scientists and resource managers gathered in Monterey, California, in August 2009, to discuss ways to manage the cumulative impacts of noise and other threats to whales and other marine life. We, the undersigned participants of this workshop, believe that reducing ocean noise is an achievable goal that will help marine life cope with less tractable threats such as climate change.

Unlike other ocean contaminants, noise does not remain in the environment for very long after the source is removed (although some effects may linger), and it is often produced unintentionally.

Most major noise sources, including propeller noise from large commercial ships and seismic pulses used in oil and gas exploration, can be reduced and still produce the public benefits desired. This can be achieved through operational measures and the application of technologies that are currently, or very soon to be, commercially available. Many noise sources can also be effectively mitigated through marine spatial planning. Federally mandated reductions will help fulfill agency obligations under the Endangered Species Act, Marine Mammal Protection Act, and other statutes, and expedite the recovery of endangered and threatened species.

Therefore we urge you to ensure, as an element of the new National Oceans Policy, that no net increase in ambient noise occurs in U. S. coastal waters and that a schedule be established to realize substantial reductions in ocean noise by 2020.

Michael Bode, Ph.D.
School of Botany,
University of Melbourne,
Victoria 3010, Australia.

Christopher W. Clark, Ph.D.
I.P. Johnson Director Bioacoustics Research Program, Cornell Laboratory of Ornithology,
Cornell University,
159 Sapsucker Woods Road,
Ithaca, NY 14850, USA.

Justin Cooke, Ph.D.
Centre for Ecosystem Management Studies
Höllenbergstr. 7
79312 Windenreute
Germany

Larry B. Crowder, Ph.D.
Stephen Toth Professor of Marine Biology
Duke University Marine Lab
Duke Center for Marine Conservation
135 Duke Marine Lab Road
Beaufort, NC 28516, USA

Terrence Deak, Ph.D.
Associate Professor
Behavioral Neuroscience Program
Department of Psychology
SUNY-Binghamton
Binghamton, NY 13902-6000, USA

Jeffrey E. Green, M.Sc., R.P. Biol., P. Biol.
Senior Principal, Environmental Management
Stantec
4370 Dominion Street 5th Floor
Burnaby, BC, V5G 4L7, Canada.

Lorne Greig, M.Sc.
Senior Systems Ecologist
ESSA Technologies Ltd.
77 Angelica Avenue,
Richmond Hill, ON L4S 2C9, Canada

John Hildebrand, Ph.D.
Scripps Institution of Oceanography
University of California San Diego
Ritter Hall 200E
8635 Kennel Way
La Jolla, CA 92093-0205

Carrie Kappel
Assistant Project Scientist
National Center for Ecological Analysis and Synthesis
University of California, Santa Barbara
735 State Street, Suite 300
Santa Barbara, CA 93101, USA

Kristy J. Kroeker
PhD candidate: Micheli Lab
Hopkins Marine Station
Stanford University
100 Oceanview Blvd
Pacific Grove, CA, 93950

Lisa L Loseto, PhD,
NSERC Post Doctoral Fellow,
School of Earth and Ocean Sciences,
University of Victoria,
Victoria BC, V8W 3V6, Canada

Marc Mangel, PhD,
Distinguished Professor of Mathematical Biology; Director, Center for Stock Assessment Research.
Department Applied Mathematics & Statistics
The Jack Baskin School of Engineering
University of California
Santa Cruz, CA 95064, USA

Jose Javier Ramasco, Ph.D.
ISI Foundation,
Viale S. Severo 65,
10133 Torino, Italy

Randall R. Reeves, Ph.D.
Chairman, IUCN/SSC Cetacean Specialist Group; Member of Committee of Scientific Advisers, Marine Mammal Commission.
27 Chandler Lane,
Hudson, Quebec, J0P 1H0, Canada.

Robert Suydam, Ph.D.
P.O. Box 1132
Barrow, AK 99723, USA

Linda S. Weilgart, Ph.D.
Dalhousie University, Dept. of Biology.
1355 Oxford St.
Halifax, Nova Scotia, B3H 4J1, Canada.

cc: Gary Locke, Secretary of Commerce
Ken Salazar, Secretary of Interior
Nancy Sutley, Chair, Interagency Ocean Policy Task Force
Dr. Jane Lubchenco, Undersecretary for Oceans and Atmosphere, NOAA Administrator
Lisa P. Jackson, Administrator of EPA
Sen. Maria Cantwell, Chair, Oceans Subcommittee, Senate Commerce Committee
Sen. Olympia Snowe, Ranking Member, Oceans Subcommittee, Senate Commerce Committee
Rep. Madeleine Bordallo, Chair, Insular Affairs, Oceans and Wildlife Subcommittee, House Natural Resources Committee
Rep. Henry Brown, Jr., Ranking Member, Insular Affairs, Oceans and Wildlife Subcommittee, House Natural Resources Committee

okeanos - Stiftung für das Meer
Auf der Marienhöhe 15
D-64297 Darmstadt

STIFTUNG FÜR DAS MEER
okeanos

Telefon +49- 6151-918 20 23
Telefax +49- 6151-918 20 19
mail@okeanos-stiftung.org
www.okeanos-stiftung.org

24th November 2009 Letter the Interagency Ocean Policy Task Force

Participants of the Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals: From Ideas to Action
c/o Okeanos - Stiftung für das Meer / Foundation for the Sea (Workshop Sponsor)
Auf der Marienhöhe 15
D-64297 Darmstadt, Germany

mail@okeanos-stiftung.org

24th November 2009

Ms. Nancy Sutley
Chair, Council on Environmental Quality
Chair, Interagency Ocean Policy Task Force
The White House
1600 Pennsylvania Ave., N.W.
Washington, DC 20500

Dear Chairwoman Sutley and Members of the Interagency Ocean Policy Task Force:

We write to advise you of the results of an international, multi-disciplinary workshop held in Monterey Bay, California, earlier this year, on the cumulative impacts of ocean noise and other threats to marine life. We, the undersigned participants of the workshop, believe our work bears upon the framework you are developing for coastal and marine spatial planning, and we wish to offer guidance and tools to support your important efforts.

As you know, human activities are altering the world's oceans at an unprecedented magnitude and speed. Ocean acidification and climate change are likely to have widespread, adverse impacts on marine food webs. These impacts will further disrupt ecosystems already stressed by pollution, invasive species, overfishing, noise, and the destruction of sea-floor habitats, posing a grave threat not only to ocean health, but also to human welfare. As we noted in our October 7 letter to President Obama (attached here), we believe that reducing ocean noise is an achievable goal that will strengthen the resiliency of marine life to less tractable threats.

In Monterey, we began to develop a novel set of tools for assessing the cumulative effects of human activities, including undersea noise from all sources, on cetaceans. (Details of this emerging methodology are provided in the attached supporting documents.) In summary, the necessary data and techniques are available to produce regional maps representing the distribution and intensity of noise in the oceans. These can be combined with other maps currently available for fishing, offshore development, contaminant levels, and other threats to ecosystem health, to determine overall exposure of populations of animals. For well-studied species, the information can be incorporated into population models to provide meaningful advice concerning the cumulative impacts of multiple stressors. Findings from both these maps and models can be applied to other data-poor species. While we focused on cetaceans, many of these techniques can be applied to other species groups and ecosystems, and all of these tools are directly relevant to regional marine spatial planning.

Furthermore, we believe that noise, which is essentially a form of habitat destruction, can be effectively mitigated through marine spatial planning in the same way as other impacts related to human activities. The available scientific information supports action to mitigate impacts in areas with particularly high levels of ocean noise, as well as to cap noise levels in important habitat, such as whale feeding and calving areas. Such reductions in noise will help fulfill agency obligations under the Endangered Species Act, Marine Mammal Protection Act, and other statutes, and expedite the recovery of endangered and threatened species.

Marine spatial planning could also be applied to great effect in areas of rapidly increasing human use. For example, expanding activity in the Arctic – particularly from shipping, seismic exploration, and fishing – threatens to acoustically urbanize what was only recently a near-pristine environment, where the calls of endangered bowhead and beluga whales traveled across hundreds or even thousands of miles of icy ocean.

We therefore urge you to include ocean noise in the framework for coastal and marine spatial planning and in associated guidelines for cumulative impact assessment. We also ask that you recommend setting a cap on ocean noise in substantial portions of the Arctic and in important marine habitat in US waters, as well as upon the high seas, preserving the biological integrity of these areas for the continued health of ocean ecosystems and the well-being of the people who depend upon them. Finally, in support of your efforts, we offer our ongoing work on threat mapping and cumulative impact assessment, as described above.

Michael Bode, Ph.D.
School of Botany,
University of Melbourne,
Victoria 3010, Australia.

Christopher W. Clark, Ph.D.
I.P. Johnson Director Bioacoustics Research Program, Cornell Laboratory of Ornithology,
Cornell University,
159 Sapsucker Woods Road,
Ithaca, NY 14850, USA.

Justin Cooke, Ph.D.
Centre for Ecosystem Management Studies
Höllenbergstr. 7
79312 Windenreute
Germany

Larry B. Crowder, Ph.D.
Stephen Toth Professor of Marine Biology
Duke University Marine Lab
Duke Center for Marine Conservation
135 Duke Marine Lab Road
Beaufort, NC 28516, USA

Terrence Deak, Ph.D.
Associate Professor
Behavioral Neuroscience Program
Department of Psychology
SUNY-Binghamton
Binghamton, NY 13902-6000, USA

Lorne Greig, M.Sc.
Senior Systems Ecologist
ESSA Technologies Ltd.
77 Angelica Avenue,
Richmond Hill, ON L4S 2C9, Canada

Carrie Kappel
Assistant Project Scientist
National Center for Ecological Analysis and Synthesis
University of California, Santa Barbara
735 State Street, Suite 300
Santa Barbara, CA 93101, USA

Lisa L Loseto, PhD,
NSERC Post Doctoral Fellow,
School of Earth and Ocean Sciences,
University of Victoria,
Victoria BC, V8W 3V6, Canada

Jose Javier Ramasco, Ph.D.
ISI Foundation,
Viale S. Severo 65,
10133 Torino, Italy

Jeffrey E. Green, M.Sc., R.P. Biol., P. Biol.
Senior Principal, Environmental Management
Stantec
4370 Dominion Street 5th Floor
Burnaby, BC, V5G 4L7, Canada.

John Hildebrand, Ph.D.
Scripps Institution of Oceanography
University of California San Diego
Ritter Hall 200E
8635 Kennel Way
La Jolla, CA 92093-0205

Kristy J. Kroeker
PhD candidate: Micheli Lab
Hopkins Marine Station
Stanford University
100 Oceanview Blvd
Pacific Grove, CA, 93950

Marc Mangel, PhD,
Distinguished Professor of Mathematical Biology; Director, Center for Stock Assessment Research.
Department Applied Mathematics & Statistics
The Jack Baskin School of Engineering
University of California
Santa Cruz, CA 95064, USA

Randall R. Reeves, Ph.D.
Chairman, IUCN/SSC Cetacean Specialist Group; Member of Committee of Scientific Advisers, Marine Mammal Commission.
27 Chandler Lane,
Hudson, Quebec, J0P 1H0, Canada.

William H. Satterthwaite
Postdoctoral Researcher
Center for Stock Assessment Research
Department Applied Mathematics & Statistics
The Jack Baskin School of Engineering
University of California
Santa Cruz, CA 95064, USA

Robert Suydam, Ph.D.
P.O. Box 1132
Barrow, AK 99723, USA

Linda S. Weilgart, Ph.D.
Dalhousie University, Dept. of Biology.
1355 Oxford St.
Halifax, Nova Scotia, B3H 4J1, Canada.

Enclosures:
1) October 7 letter from the Participants of the Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals: From Ideas to Action to President Obama
2) Kappel, C., Alter, E., Brewer, P., Deak, T., Erbe, C., Fristrup, K., Harrison, J., Hatch, L., Hildebrand, J. & Kroeker, K.J. 2009. Mapping Cumulative Threats to Cetaceans from Ocean Noise and Other Stressors. *Report of the Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals: From Ideas to Action.*
3) Cooke, J., Bode, M., Clark, C., Crowder, L., Green, J., Loseto, L., Mangel, M., Munns, W., Ramasco, J.J., Reeves, R., Satterthwaite, W.H., Suydam, R., Taylor, B., Weilgart, L., Wright, A.J. 2009 Modeling the Population Effects of Cumulative Impacts. *Report of the Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals: From Ideas to Action.*
4) Wright, A.J., Bode, M., Loseto, L., Ramasco, J.J., Munns, W., Deak, T. & Kroeker, K.J. 2009. A Model of Cumulative Impacts on an Individual Marine Mammal. *Report of the Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals: From Ideas to Action.*

cc: Gary Locke, Secretary of Commerce
Ken Salazar, Secretary of Interior
Dr. Jane Lubchenco, Undersecretary for Oceans and Atmosphere, NOAA Administrator
Lisa P. Jackson, Administrator of EPA
Sen. Maria Cantwell, Chair, Oceans Subcommittee, Senate Commerce Committee
Sen. Olympia Snowe, Ranking Member, Oceans Subcommittee, Senate Commerce Committee
Rep. Madeleine Bordallo, Chair, Insular Affairs, Oceans and Wildlife Subcommittee, House Natural Resources Committee
Rep. Henry Brown, Jr., Ranking Member, Insular Affairs, Oceans and Wildlife Subcommittee, House Natural Resources Committee

Mapping Cumulative Threats to Cetaceans from Ocean Noise and Other Stressors

Carrie Kappel, Elizabeth Alter, Peter Brewer, Terrence Deak, Christine Erbe,
Kurt Fristrup, Jolie Harrison, Leila Hatch, John Hildebrand, Kristy Jean Kroeker

1. Framework

Spatio-temporal management of noise and other stressors is increasingly recognized as a critical strategy for mitigating cumulative impacts[1] on marine species, including cetaceans (whales and dolphins). This strategy requires 1) identification, assessment, and mapping of quantitative information on both habitat distributions and anthropogenic threats, and 2) synthesis of these datasets to produce vulnerability maps (Agardy et al. 2007). Though data on noise-producing sources exist for many regions of the oceans, these data have never been synthesized with the goal of deriving comprehensive annual or seasonal estimates of cumulative noise exposure, or integrated with exposure maps for other anthropogenic stressors.

Consequently, we aimed to:

1. Develop robust methods for cumulatively mapping annual or seasonal anthropogenic noise exposure from a full suite of diverse sources.
2. Derive methods for integrating spatial mapping of anthropogenic stressors with quantitative vulnerability assessments for cetacean species.
3. Develop one or several regional case studies for both (1) and (2).

Below we describe progress toward these goals and outline an approach to meeting them in future work.

Recent approaches to mapping cumulative impacts of human activities on marine ecosystems (e.g., Halpern et al. 2008; Halpern et al. 2009) provide a useful template for accomplishing these objectives. Specific aspects of this approach that could be applied to the problem of cumulative noise include implementation of a framework for weighting and summation of maps of the distribution and intensity of diverse stressors; the design and use of expert surveys; and organization of threats by activity (e.g. seismic exploration, dredging). Halpern et al. (2008) have produced a global map of annual cumulative impacts from human activities including fishing, climate change, pollution, and other stressors. At the regional scale, a research team at the National Center for Ecological Analysis and Synthesis (NCEAS) has completed an assessment of cumulative anthropogenic threats for the California Current Ecosystem (Halpern et al. 2009) and is undertaking a similar project for the state and federal waters off of Massachusetts. These projects have not previously included anthropogenic noise as a data layer. Developing a map of noise sources and impacts that could be directly integrated with these efforts would be of great utility for managers and regulators.

An important additional consideration specific to noise is the problem of combining data from noise sources characterized by different frequencies, duration, duty cycle[2] and loudness. Participants agreed that a weighting and integration scheme should be developed to produce a noise pollution index that can be used to compare across noise sources with very different characteristics. Differences in temporal signatures are also important: while averaging impacts on an annual basis will make sense for some noise sources, incorporating seasonal signatures may be more appropriate for others.

[1] Cumulative impacts are the total suite of impacts arising from two or more threats acting in combination upon a population. They do not necessarily have to occur at the same time or even in the same location to present a cumulative challenge to the population.

[2] Duty cycle is the portion of time during which the noise-making source is operated.

In addition, two general classes of noise-producing activities have very different impacts at the biological level. Chronic or continuous noise sources (such as shipping) can result in masking of sounds produced for communication, foraging or navigation, reducing habitat value indefinitely in areas of high use. Acute noise sources, such as explosions, which have higher peak noise levels, but usually more localized and short term use, can cause disturbance and result in injury and/or death in certain circumstances[3]. Noise data falling into these two categories should be compiled into two separate data layers during the analysis and mapping (though the two layers could easily be integrated into one noise layer in a final analysis). Chronic noise should be measured relative to ambient sound in the oceans, which differs regionally and seasonally. Therefore, data on ambient sound are needed at the same spatial and temporal scale as chronic noise data.

2. Classifying and determining data sources for noise-producing activities

Noise sources were classified by human activity, grouping activities that were deemed to have similar noise signatures in terms of frequency and duration. In some cases broadly defined activities produce multiple kinds of noise, and these noise components must be treated under different categories. For example, trawling produces both vessel noise and noise associated with the bottom trawl itself: the vessel noise is captured in Small and mid-size vessels and the trawl noise in Mobile bottom gear. Similarly, naval training exercises may involve vessel noise, active sonar and explosions.

We identified the following categories of prevalent sources of noise:

1. Shipping;
2. Small and mid-sized vessels (including fishing, recreational, whale-watching, law enforcement, and research vessels);
3. Seismic airguns;
4. Ice breakers;
5. Military sonar;
6. Industrial construction (including dynamic positioning, drilling, pile driving and thruster use in constructing coastal and energy infrastructure (including renewable and nonrenewable energy sources);
7. Explosions (including military, dynamite fishing and rig decommissioning);
8. Mobile bottom gear (trawling and dredging); and
9. Acoustic harassment devices used in aquaculture and other operations.

We discussed how quantitative data on these various noise-producing activities might be obtained at both regional (using Massachusetts Bay as a focal area) and global scales. For each noise source, potential sources of data for the spatial and temporal extent of the activity and the noise signature (sound profile) were identified. Table 1 summarizes these potential data sources.

3. Vulnerability measures

We next considered how to develop quantitative vulnerability assessments for cetaceans that could be integrated with spatial maps of noise and other stressors. We discussed the utility of analyzing stressors both for individual species (when data allows) and for species groups based on hearing or noise sensitivity; taxonomy (e.g. beaked whales); management considerations (e.g. threatened or

[3] As a further note, propagation of sound underwater changes the characteristics of highly repetitive, loud, low-frequency-dominant acute sources, such that they become less discrete temporally and could, at some distance from the source, mask communication signals produced by low-frequency active marine animals, (i.e. effectively becoming a chronic source).

endangered species); or behavioral characteristics related to foraging, migration, and other behaviors.

Drawing on the Millennium Ecosystem Assessment's definition, the group defined vulnerability as having three components: exposure, sensitivity and resilience. Exposure determines the probability that a species or group of species will encounter a given stressor. Sensitivity determines how likely the species or group is to be affected negatively by that stressor. Coping strategies such as avoidance behavior can limit exposure to stressors, but do not necessarily reduce the adverse health consequences of stressors. Finally resilience refers to the ability of the individual or group of individuals to thrive in the face of stressors and/or rebound following stressor exposure. This recovery could have both short and long term components: recovery time may measure either the time required for a return to normal physiological levels and behavior, represented by full recuperation of the individual (hours to weeks), or for population recovery, which may take years.

We concluded that, due to data limitations, expert surveys would be necessary to evaluate species- or group-specific vulnerabilities to noise and other stressors. The framework and the methods for expert elicitation we discussed build on those of Halpern et al. (2007) and Teck et al. (in press). In this framework, experts would assess the vulnerability of a particular species or group of species to each noise class, or possibly to the two broad layers of noise classes (chronic versus acute), using a set of vulnerability measures. These vulnerability measures would then be weighted and combined into an overall vulnerability score. Scores can be averaged across all threats to give an average vulnerability rank per species or group, or averaged across species or groups to rank threats. These vulnerability scores are then used to build overall cumulative impact scores.

To map cumulative impacts, three data inputs are required: distribution and intensity of the stressors, distribution and density of the species or group (here modeled using habitat suitability maps), and the vulnerability scores described above. Methods and approaches for mapping stressors other than noise are described in Halpern et al. (2008; 2009). An approach to modeling cumulative noise is described above, and potential sources of data are reported in Table 1. Predicted cetacean densities (in the absence of stressors) would come from habitat suitability or predicted density models when available and deemed reliable (e.g., Barlow et al. 2009). These models use the relationship between observed animal densities with in situ and/or remotely sensed oceanographic conditions across multiple years of survey data to predict average or future distributions.

With these data in hand, cumulative impact would be calculated for each map pixel and threat/species combination by multiplying across predicted density, threat intensity, and vulnerability of species to that threat. A species-specific cumulative impact score could then be derived by summing across threats; likewise, overall cumulative impact scores could be derived by first averaging across species and then summing across threats. The output of these calculations is a set of maps of cumulative impact, for individual species, groups of species, and for all, or subsets of, stressors. Together these maps and associated analyses can help scientists and managers to understand the spatial distribution of threats, which species are most vulnerable to cumulative impacts and where, and which stressors contribute most to cumulative impacts.

A broad suite of factors influencing species- or group-specific vulnerability to particular stressors was discussed for potential inclusion in vulnerability assessments. These included density of population; residence time/mobility/behavioral response; frequency of stressor exposure relative to response time; predictability of stressor; avoidability; controllability; aversiveness; magnitude of stress response; and index of reproduction. Predictability and controllability of a stressor are key factors in rodent experimental systems (Maier and Watkins 2005). In addition, laboratory results have shown that repeated exposure to stressors that are similar in type often leads to substantial

habituation to that threat, while repeated exposure to very different stressors is associated with sensitized outcomes (Weinberg et al. 2009). The magnitude of the stress response can be used as a predictor of certain adverse health outcomes. Consequently, repeated exposure to unpredictable, inescapable threats arising from categorically distinct sources (chemical threats versus more psychological threats such as noise, for example) would be expected to have the greatest cumulative impact, physiologically, on exposed individuals (Deak 2007).

After considering this array of factors and the original Halpern et al. (2007) vulnerability framework, we decided to build the cumulative impact score from the following:

1. Spatial extent of impact (of a single event);
2. Frequency of impact (single event);
3. Trophic impact (whether predators and/or prey of a species are also affected);
4. Population impact (for example, percent change in abundance, reproductive output or another measure of severity of effect on demographic parameters – see Cooke et al. 2009); and
5. Recovery time (behavioral and physiological) of an exposed individual.

Per the Millennium Ecosystem Assessment definition of vulnerability, spatial extent and frequency of impact describe the risk of exposure to a stressor. The last three describe species- or group-specific sensitivity and resilience to a particular stressor at the community, population and individual levels.

The current approach assumes that these five factors combine linearly to give a measure of vulnerability, and similarly that all stressors combine additively (Halpern et al. 2007, Halpern et al. 2008, Teck et al. in press). However, we know that some stressors interact to produce synergistic or antagonistic effects (those which are greater or smaller than what one would expect from simply summing the stressors). Ultimately it will be desirable to incorporate some measure of synergistic effects of multiple stressors, either within the vulnerability assessment or the cumulative impact model itself.

4. Species-specific considerations

Producing species-specific vulnerability maps using the process outlined above requires mapping of species distributions. The working group noted that in the case of species distributions (as opposed to the spatial distribution of ecosystems), distributions of threats and species distributions may be negatively correlated if animals are actively avoiding certain areas where stressors are concentrated. For this reason, when building cumulative impact maps, it may be preferable to use predictive maps of habitat suitability in addition to or in place of density maps built from observations. It should be noted, however, that predictive density or habitat suitability maps are not necessarily free of the influence of stressors on species distributions, because they are built based on relatively recent observations of species distribution and density, which may have been affected by human activities. For some species for which very few data exist, it may be necessary to use expert knowledge to build predictive habitat suitability indices. Another alternative would be to produce species-specific cumulative risk maps, without respect to the species' actual or predicted distributions. These maps would show the potential risk to the species in terms of cumulative impacts, for all locations across a study region. Finally, it was noted that survey data could potentially be used post-hoc to test correlations between actual (as opposed to predicted) distributions and noise exposure. Such analyses would need to be done very carefully though, as many factors other than noise exposure contribute to determining distributions.

5. Integration with population models

This mapping framework can eventually be combined with the population modeling framework (Cooke et al. 2009) in a variety of ways. First, the outputs of population models can provide quantitative information to supplement or replace expert judgment on the population impact vulnerability measure (and potentially others). Second, spatially explicit population models can be used to map vulnerability to each stressor at each location and time (e.g., breeding and feeding seasons). This would generate temporal and spatial vulnerability fields for each species with respect to each stressor. These vulnerability fields can then be used as a spatial weighting factor in the cumulative impact model, as described above. Finally, cumulative risk maps generated through the mapping analysis may serve as inputs to a spatially explicit individual or agent-based simulation.

6. Next steps

These methods will be best developed and tested through focused case studies. Given the availability of existing data on human activities, noise sources, and a vulnerable cetacean population (the North Atlantic right whale), Massachusetts Bay represents an ideal initial case study. Mapping of cumulative impacts of human activities is ongoing (NCEAS), as is noise monitoring and modeling (Stellwagen Bank National Marine Sanctuary). As noted in the population modeling document, the population of North Atlantic right whales is well-studied, making it suitable for detailed population modeling. Finally, there is a recognized need for an approach to quantifying cumulative impacts to this population.

Additional case studies could concentrate on Southern resident killer whales in the Puget Sound area or baleen whales in the Southern California Bight. Either of these case studies could build from published work on the cumulative impacts of human activities within the California Current (Halpern et al. 2009), extensive data on cetacean populations, predictive habitat maps for cetaceans, and ongoing noise monitoring and modeling.

Finally, the framework outlined above could be applied at the global scale to produce a global map of cumulative risks to cetaceans from human activities, building on the global map of Halpern et al. (2008) by incorporating, among other stressors, a comprehensive data layer on the distribution and relative intensity of anthropogenic noise.

7. References

Agardy, T., Aguilar Soto, N., Cañadas, A., Engel, M., Frantzis, A., Hatch, L., Hoyt, E., Kaschner, K., LaBrecque, E., Martin, V., Notarbartolo di Sciara, G., Pavan, G., Servidio, A., Smith, B., Wang, J., Weilgart, L., Wintle, B. and Wright, A. 2007. *A Global Scientific Workshop on Spatio-Temporal Management of Noise. Report of the Scientific Workshop*. 44 pages.

Barlow, J., Balance, L., Forney, K., Redfern, J., Reilly, S., Fiedler, P., Ferguson, M. & Becker, E. 2009. *Predictive Modeling of Marine Mammal Density from Existing Survey Data and Model Validation using Upcoming Surveys.* NOAA Technical Memorandum 444. 196 pp.

Cooke, J., Bode, M., Clark, C., Crowder, L., Green, J., Loseto, L., Mangel, M., Munns, W., Ramasco, J., Reeves, R., Satterthwaite, W.H., Suydam, R., Taylor, B., Weilgart, L., Wright, A.J. 2009 Modeling the Population Effects of Cumulative Impacts. *Report of the Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals: From Ideas to Action.*

Deak, T. 2007. From classic aspects of the stress response to neuroinflammation and sickness: implictions for individuals and offspring. *International Journal of Comparative Psychology* 20:96-110.

Halpern, B.S., Walbridge S, Selkoe, K.A., Kappel, C.A., Micheli, F. D'Agrosa, C., Bruno, J.F., Casey, K.S., Ebert, C., Fox, H.E., Fujita, R., Heinemann, D., Lenihan, H.S., Madin, E.M.P., Perry, M.T., Selig, E.R., Spalding, M., Steneck, R. & Watson, R. 2008. A global map of human impact on marine ecosystems. *Science* 319:948-952.

Halpern, B.S., Kappel, C.V., Selkoe, K.A., Micheli, F., Ebert, C.M., Kontgis, C., Crain, C.M., Martone, R.G., Shearer, C. & Teck, S.J. 2009. Mapping cumulative human impacts to California Current marine ecosystems. *Conservation Letters* 9999.

Halpern, B.S., Selkoe, K.A., Micheli, F. & Kappel, C.V. 2007. Evaluating and Ranking the Vulnerability of Global Marine Ecosystems to Anthropogenic Threats. *Conservation Biology* 21:1301.

Maier, S.F. & Watkins, L.R. 2005. Stressor controllability and learned helplessness: the roles of the dorsal raphe nucleus, serotonin, and corticotropin-releasing factor. *Neuroscience and biobehavioral reviews* 29:829-841.

Millennium Ecosystem Assessment. 2005. *Ecosystems and human well-being: policy responses.* Island Press, Washington, D.C.

Weinberg, M.S., Bhatt, A.P., Girotti, M., Masini, C.V., Day, H.E.W., Campeau, S. & Spencer, R.L. 2009. Repeated ferret odor exposure induces different temporal patterns of same-stressor habituation and novel-stressor sensitization in both hypothalamic-pituitary-adrenal axis activity and forebrain c-fos expression in the rat. *Endocrinology* 150:749.

Teck, S.J., Halpern, B.S., Kappel, C.K., Micheli, F., Selkoe, K.A., Crain, C.M., Martone, R., Shearer, C., Arvai, J., Fischhoff, B., Murray, G., Neslo, R. & Cooke, R. In press. Using expert judgment to assess the vulnerability of marine ecosystems in the California Current. *Ecological Applications.*

Acknowledgements: This paper arose from the Workshop on Cumulative Impacts/ Effects of Anthropogenic Stressors on Marine Mammals: From Ideas to Action, 26-29 August, 2009. It could not have been written without either the generous support of the sponsor, Okeanos – Foundation for the Sea, or the contributions from the many participants, both at the meeting and through reviews of early versions. The views expressed in this paper are those of the authors alone and do not represent those of any institution or agency, governmental or otherwise, that they may be affiliated with.

Table 1. Potential data sources for noise-producing activities.

	Subcategory	Chronic vs acute	Temporal aspects	Source of spatial data	Source of acoustic characterization data	Comments
Shipping	Large, ocean-going	Chronic	Annual averaging okay for metric (no seasonal component)	AIS (coastal) and HITS (pelagic) data	Generic sound profile data for a large ship plus propagated noise field, e.g. Scrimger & Heitmeyer, JASA 1991.	
Ice breakers		Chronic	Seasonal	Canadians keep track of ice breakers in Arctic; Antarctic - use base locations	Christine Erbe can provide information	
Small to mid-sized vessels	Fishing	Chronic	Seasonal	MA: NMFS and MA DMF; Global, CA: spatial fishing data from Halpern et al. 2008, 2009	Generic sound profile data for small/mid-sized vessels	
	Recreational	Chronic	Seasonal	Port or harbor size as a proxy for source and diffuse away from port. Number of boat licences (not boat driver licences) from county office.	Generic sound profile data for small/mid-sized vessels	Could Google Earth be used to count boats in harbor? Diffusive path may be linear along coast rather than radiating from port. Majority of boats stay within a few nm from harbor.
	Whale-watching	Chronic	Seasonal	Average across a localized area of regional activity based on number of boats or number of operator licences	Generic sound profile data for small/mid-sized vessels. Christine Erbe could provide data.	May need to consider correction to source level to reflect the fact that noise is not distributed randomly with respect to animals.
	Law enforcement	Chronic	No seasonal component		Generic sound profile data for small/mid-sized vessels	
	Research	Chronic	Seasonal		Generic sound profile data for small/mid-sized vessels	

okeanos - Stiftung für das Meer
Auf der Marienhöhe 15
D-64297 Darmstadt

Telefon +49- 6151-918 20 23
Telefax +49- 6151-918 20 19
mail@okeanos-stiftung.org
www.okeanos-stiftung.org

	Subcategory	Chronic vs acute	Temporal aspects	Source of spatial data	Source of acoustic characterization data	Comments
	Support vessels for construction/ maintenance	Chronic	No seasonal component		Generic sound profile data for small/mid-sized vessels	
Seismic exploration		Chronic	Seasonal in some regions (Arctic)	Global database of seismic vessels by region (World Geophysical News): # vessels/mo	Use acoustic signature of "average" industry vessel ; signatures of seismic arrays from Christine Erbe	
Military sonar	Mid Frequency Acoustic	Acute	No seasonal component	Hours of use of 53C (NOAA permitting)	Navy propagation models	
	Low Frequency Acoustic	Acute	No seasonal component	Extrapolate from pattern of historical use	Navy propagation models	
Explosions	Military	Acute	No seasonal component	NOAA permitting has data on ordinances used per exercise		No propagation model probably needed
	Dynamite fishing	Acute	No seasonal component	Hildebrand map for Indian Ocean		
	Rig de-commissioning	Acute	No seasonal component			
Mobile bottom gear	Trawling	Chronic	Seasonal	Use data from Halpern et al. from logbook reports/NMFS information for MA	Acoustic signature can come from Leila Hatch, could then be translated into global context	
Aquaculture	Acoustic harrassment	Acute	No seasonal component	MA and CA: Halpern et al. 2009 data from Google Earth combined with town data	Acoustic signature from manufacturer	
Construction/ industrial activites	Liquefied Natural Gas	Chronic	No seasonal component	Permitting agency -- Army Corps?		

okeanos - Stiftung für das Meer
Auf der Marienhöhe 15
D-64297 Darmstadt

Telefon +49- 6151-918 20 23
Telefax +49- 6151-918 20 19
mail@okeanos-stiftung.org
www.okeanos-stiftung.org

Subcategory	Chronic vs acute	Temporal aspects	Source of spatial data	Source of acoustic characterization data	Comments
Wind energy	Chronic	No seasonal component	State permitting/coastal planning. CA - wind E potential map; MA - Ocean Mgt Plan wind E areas	Generic sound profile data for turbines	
Tidal energy	Chronic	No seasonal component	State permitting/coastal planning. MA - Ocean Mgt Plan proposed tidal energy locations		
Wave energy	Chronic	No seasonal component	State permitting/coastal planning. CA - wave energy potential map		
Dynamic positioning	Chronic	No seasonal component			
Land-based construction	Chronic	No seasonal component	NOAA Environmental Sensitivity Index (hardened shoreline).		
Drilling (fixed and mobile)	Acute	No seasonal component	NOAA oil & gas permitting; World Geophysical News		
Pile-driving	Acute	No seasonal component	Presence of large harbors/ports and assume some level of periodic pile driving.	Christine Erbe can provide sound characteristics.	Use mean spectrum and attach some information on duty cycle. Keep track of peak levels in addition to averaging out.
Dredging	Acute	No seasonal component	Presence of large harbors/ports and assume some level of dredging		

okeanos - Stiftung für das Meer
Auf der Marienhöhe 15
D-64297 Darmstadt

Telefon +49- 6151-918 20 23
Telefax +49- 6151-918 20 19
mail@okeanos-stiftung.org
www.okeanos-stiftung.org

okeanos - Stiftung für das Meer
Auf der Marienhöhe 15
D-64297 Darmstadt

Telefon +49- 6151-918 20 23
Telefax +49- 6151-918 20 19
mail@okeanos-stiftung.org
www.okeanos-stiftung.org

Modeling the Population Effects of Cumulative Impacts

Justin Cooke, Michael Bode, Chris Clark, Larry Crowder, Jeffrey Green, Lisa Loseto,
Marc Mangel, Wayne Munns, Jose J. Ramasco, Randy Reeves, William H. Satterthwaite,
Robert Suydam, Barb Taylor, Lindy Weilgart, Andrew J. Wright

1. Summary

While the excessive hunting of the 18th-20th centuries has been brought largely under control, marine mammals − whales, dolphins, porpoises, pinnipeds and sirenians − now face a widening range of threats or stressors that together could jeopardize the survival of populations: entrapment and entanglement in fishing gear; collisions with vessels; noise from shipping, seismic surveys, sonar and other sources; toxic contaminants; ecological changes associated with climate change, fishing and pollution; and various other types of habitat alteration and degradation.

Assessment and management approaches for marine mammals have focused to date on direct mortalities or removals. These approaches need to be extended to cover sublethal effects, when individuals are not always killed (or otherwise removed from populations) immediately, but their health and condition is compromised, leading to reduced rates of individual survival, growth and reproduction. The survival of marine mammal populations depends on whether the cumulative impact of these threats or stressors can be contained within bounds that the populations can sustain. Otherwise, populations will decline, and species will disappear from parts of their current range, or even entirely.

Approaches to the management of cumulative impacts[1] on marine mammal population will require, among other inputs, results from population modeling that incorporates sublethal effects into survival and reproductive rates. Such modeling can yield population projections under different scenarios of threat levels and management action, and/or it can estimate levels of cumulative impact that are and are not consistent with population recovery or survival. This document outlines an approach to developing such models and proposes two case studies: North Atlantic right whales in the western Atlantic and "southern resident" killer whales in the eastern North Pacific.

2. Introduction

The days when species after species of whales and seals were hunted to the brink of extinction are over, but in the 21st century marine mammals − whales, dolphins, porpoises, pinnipeds and sirenians − face a range of threats that together could threaten the survival of populations: entrapment and entanglement in fishing gear; collisions with vessels; noise from shipping, seismic surveys, sonar and other activities; toxic contaminants; ecological changes associated with climate change, fishing, and pollution; and various other types of habitat alteration and degradation.

The challenge is that the effect of each single adverse factor may be hard to detect but the cumulative impacts may be enough to cause the disappearance of some species from part or all of their range.

While some threats, such as vessel collisions and entanglements, are known to kill marine mammals outright, quantification of the number of deaths, especially at the global scale, is still very approximate. The impacts of more subtle stressors, such as noise, are only now beginning to be understood. Noise can cause deaths directly in special circumstances, such as when mass strandings of beaked whales are linked to the use of military mid-frequency sonar. However, sublethal effects,

[1] Cumulative impacts, in this case, are the total suite of impacts arising from two or more threats acting in combination upon a population. They do not necessarily have to occur at the same time or even in the same location to present a cumulative challenge to the population.

such as exclusion from key habitat or reduction in the range of feeding- or mating-related communication between whales, have only recently been elucidated. The potential population-level impacts of these sublethal effects have yet to be quantified.

The amount of baseline demographic data available on populations varies greatly. In some well-studied populations, such as right whales in the western North Atlantic and "southern resident" killer whales (in Washington State and British Columbia), almost every individual is known, while for most populations of beaked whales, a family of whales that seems particularly vulnerable to acoustic threats, and many other populations of cetaceans, little is known about population abundance and structure.

Gaining a full understanding of the cumulative impact of all major stressors on the survival and reproductive rates of a marine mammal population is inherently difficult even with the kind of long-term, intensive research that to date has been conducted for only a few populations. We simply do not have the luxury of first finding out everything we would like to know about a species or population and the impacts of the stressors that they are exposed to, and only then beginning to design and implement strategies to reduce or mitigate the impacts. Taking that approach would almost certainly allow species to disappear from heavily impacted regions before the exact relationships between causes and effects are understood.

Instead, we need to act on the basis of what we know or can responsibly infer − erring, where uncertainty makes it necessary, on the side of precaution − while at the same time ensuring that directed research improves understanding of key relationships and enables management and mitigation strategies to be improved in the light of new knowledge. In particular, we need to use our knowledge of the better-studied populations to guide the determination of "allowable" exposure levels in the management of other species and populations for which data are sparse. Given the large data gaps that exist, these levels will inevitably depend on a substantial amount of inference, calibrated where possible to fit the data that we have.

The concept of PBR (Potential Biological Removal) has been of great utility in managing the levels of anthropogenic mortality of cetaceans in US waters in conformity with the Marine Mammal Protection Act (MMPA). The PBR formula provides quantitative target ceilings for human-caused direct mortality (hunting, fatal entanglements, fatal ship collisions) for both data-rich and data-poor marine mammal populations, the latter through the use of reasonable default values for unknown population parameters.

Application of the PBR formula ensures that a red flag is raised for populations subject to potentially unsustainable removals, and provides a target towards which take reduction teams can work. The PBR takes explicit account of uncertainty in that the precision of population estimates, as well as their point values, enter the formula. The Revised Management Procedure (RMP) of the International Whaling Commission (IWC) is based on a similar approach.

A challenge is to extend the PBR concept to include sublethal effects, i.e., those that do not involve immediate, observable mortality, but which over time reduce survival and reproductive rates. The goal is to develop a means to specify maximum acceptable levels of cumulative impact that serve as targets or thresholds for management strategies, or provide a red flag for populations where the cumulative impact exceeds the threshold. To make this possible, we need to develop and implement ways to express the different effects − lethal and sublethal – in a common currency so that they can be added, taking account of synergies where these can be expected to occur. Maximum Cumulative Impact (MCI) would become a threshold to be promoted at the international and national level, and at the appropriate regional level for marine mammal populations whose range spans the waters of two or more countries.

The MCI concept could be used to develop specific Cumulative Impact Management Plans for populations, or it could be incorporated into the Recovery Plans developed under the MMPA, or the Conservation Plans currently being considered by the IWC, ACCOBAMS and other multilateral bodies.

This document outlines the population modeling component of the directed research needed to improve our understanding of the demographic impacts of cumulative stressors, with the ultimate goal of contributing to the development of appropriate management and mitigation targets or thresholds.

3. List of threats

The following threats or stressors contribute to the cumulative impact and should be considered in the modeling of cumulative impacts on a population, even though not all of these stressors will be significant or applicable for all populations. The list is not exhaustive.

- Vessel interactions:
  - direct mortality and serious injuries from collisions;
  - disturbance, including from research and whale watching vessels.
- Entrapments and entanglements − direct mortality and serious injuries.
- Noise:
  - direct mortality or acoustic injury (in special cases);
  - chronic stress responses, with physiological and psychological effects;
  - habitat exclusion (spatial);
  - disturbance to feeding (time lost, reduced energy intake, increased energy use);
  - obscuring sounds important for:
    - foraging;
    - breeding;
    - predator avoidance.
- Deliberate removals, e.g., by hunting and live-capture (need to be taken into account in population projections).
- Contaminants, including oil spills:
  - direct (sublethal and occasionally lethal) physiological effects including immunological health;
  - effects on fertility.
- Nutritional and health effects of habitat change resulting from:
  - commercial fishing;
  - pollution;
  - other factors, such as exposure to novel diseases or increased competition that may result from changing habitat;
  - climate change.

Even though there can be considerable uncertainty about the numbers involved, direct mortality is in principle expressible in terms of the numbers of individuals removed from the population (broken down by age class and sex as appropriate). The challenge is to quantify sublethal effects in demographic terms.

For populations whose range includes US waters, a useful step would be the inclusion, in the Stock Assessment Reports (SARs) mandated by the MMPA, of details of human activities believed to harass or injure marine mammals, that are occurring (or have occurred) in the habitat of each population. The agencies that prepare these reports (National Marine Fisheries Service and the Fish and Wildlife Service) are also responsible for authorizing such activities.

4. Aims and approaches for modeling population effects of cumulative impacts

The aims of modeling the cumulative impacts on populations include to:

- provide a framework for estimating the population-level impacts of exposures to different stressors;
- identify the populations most at risk;
- assess possible interactions of different impacts;
- determine targets or thresholds for mitigation strategies for these populations;
- develop an approach for expressing different impacts in a common currency and thereby contribute to the development of a MCI management threshold; and
- help to identify the priorities for obtaining data on stressors and populations, in terms of both the kinds of data most needed, and the areas and species of highest priority.

Approaches to modeling cumulative impacts at the population level involve several linked stages:

1. Identification of the nature and sources of threats, and mapping of stressor levels. This will typically involve mapping, *inter alia*:
   a. noise levels by frequency, duty cycle, seasonality and type of source;
   b. fishing gear deployment by type of gear;
   c. vessel traffic by size and type of vessel;
   d. levels of major contaminants based on estimated deposition patterns from point sources, atmospheric and riverine transport, etc.;
   e. indices of water quality, and occurrence of red tides and other ecotoxic events.

2. Estimation of the level of exposure of each population to each stressor based on the distribution of each population by time of year and population component. Mapping of the distribution of marine mammals will typically involve both directly relevant data (e.g., from surveys) and inferences from habitat suitability mapping to cover less well-surveyed areas.

3. Incorporation of direct mortalities into the demographic model in the obvious way (but taking account into account the sex and age composition of the mortality because the different components of a population can be disproportionately affected).

4. Characterization of the responses, both behavioral and physiological, to sublethal threats (singly and in combination), and estimation of dose-response relationships. Where relevant, also determination of the energy cost of responses, in terms of reduced caloric intake and/or increased energy expenditure (e.g., reduced feeding time or efficiency caused by noise disturbance).

5. Integration of the different types of sublethal response into one or more common condition factors, to which demographic parameters can be related.

6. Estimation of the demographic consequences of reduced condition, in terms of the following parameters:
   a. calving/pupping rate;
   b. calf/pup survival;
   c. adult survival; and
   d. age at first reproduction.

Changes in some demographic parameters are easier to detect than others. For example, calving rates can often be measured from direct calf counts or from calving intervals of known mothers. Changes in survival rate are harder to detect, requiring many years of data, but small changes near

the threshold of detection can represent the difference between a viable and non-viable population. In general, it is not safe or appropriate to assume that the harder-to-measure parameters will remain constant in the face of variations in the more easily measurable parameters. Use of general life history models to infer relationships between demographic parameters can be explored.

5. Types of data on marine mammal populations

The kinds of data that are or can be collected from marine mammal populations include:

- animal density (from surveys, supplemented with habitat suitability mapping);
- population size and structure (from surveys or from photographic or genetic identification);
- distribution and migration (from surveys and tracking data);
- visible body condition (e.g., degree of emaciation or obvious injury);
- physiological condition from biopsies (e.g., biochemical stress indicators, contaminant levels);
- reproduction (e.g., calving intervals, pup counts);
- mortality (direct observations including necropsies);
- survival rates (from longitudinal studies of individuals); and
- behavioral responses to threats.

Population models can be fit to each of these kinds of data in distinct ways. Because data on most populations are scarce, it is important that population models are able to make full use of the limited data that are available.

6. Population models

The design of population models that address cumulative impacts is to a large extent determined by the following requirements:

- incorporate lethal and sublethal effects in a consistent way, for example through a generalized condition factor;
- assimilate the available population and demographic data of different kinds, and fill data gaps;
- allow for normal demographic stochasticity (especially for small populations) and natural environmental variability;
- integrate multiple sources of uncertainty and express outcomes in probabilistic terms; and
- provide demographic projections for different scenarios of threats and mitigation.

Taken together, these requirements tend to dictate the following characteristics of the models:

- spatially explicit, to allow for incorporation of the spatial distribution of the different threats and population occurrence under various threat and mitigation scenarios to be incorporated;
- seasonally explicit, because migration patterns of most marine mammal populations lead to differential exposure to the various threats during different parts of the lifecycle (feeding, migration, breeding);
- individually-based, to allow for variation in condition of individuals within the population, to make use of data on individuals (for the better-studied populations), and to facilitate incorporation of potential interactions in threat-impact pathways;
- allow for random variation, at both the individual level (demographic stochasticity) and the population level (environmental variability); and
- partly or fully Bayesian, to allow for uncertainty in assumptions and inferred parameters (but with appropriate sensitivity analyses conducted to determine the sensitivity of the conclusions to prior assumptions).

For larger populations, demographically-structured bulk models provide an alternative to individually based models, but can become unwieldy as the number of threat factors and consequent subdivisions of the population into different states of health or vitality increases.

An example of the internal structure of such a model is outlined in Wright et al. (2009). The results of such a model can be expressed in several different ways, depending on the management questions to be addressed, such as:

- population projections under different scenarios of stressor levels and mitigation; and
- estimation of the maximum cumulative impact that would be consistent with population recovery or persistence.

The models can be used to assess the sensitivity and resilience of populations to specific threats or stressors. The sensitivity is the impact on the population, expressed for example in terms of the effect on population growth or decline rate of a unit increase in stressor level. The resilience of the population can be expressed in terms of the predicted recovery time following reduction of a stressor by a specified amount. Along with exposure, sensitivity and resilience are component factors of what is usually referred to as the vulnerability of a population to a specific stressor.

In addition, the models can be used to construct temporal and spatial vulnerability fields for each species with respect to each stressor. For each geographic location and time of year, the local vulnerability to a stressor is a function of the relative occurrence of each population component at that location and time, multiplied by the sensitivity (in terms of demographic impact) of those individuals to a unit change in stressor level. The latter is in turn a function of habitat usage at the given time and place (e.g. feeding, nursing, migration). The constructed vulnerability fields can be used as input into mapping exercises that generate maps of cumulative impact by location and season, and maps of the relative importance of reducing stressors as a function of season and location. This will in turn be an important input into marine spatial planning (MSP) processes.

7. Case studies

The most effective way to develop a population modeling approach for cumulative threats is to start with specific cases. The cases should have the following characteristics:

- individuals are subject to multiple stressors, which in combination threaten the population; and
- data-rich (both in terms of the populations themselves and the stressors they are exposed to).

Based on these criteria the following case studies are recommended:

North Atlantic right whales in the western North Atlantic.
The population is well studied; the majority of individuals are known; photo-id, genetic and other data have been collected for over 20 years; the data time series is long enough to estimate demographic parameters with high precision. The reproductive rate is low and variable. The population is believed to be at a small fraction of historical abundance and is recovering only slowly or not at all. The main known threats are vessel collisions, entanglements in fishing gear, and noise (which has been shown to mask communications relevant to feeding). Food availability may be subject to natural decadal climatic variations producing regular nutritional challenges that reduce reproduction during these periods of lower food availability. This pattern would be exacerbated in some climate change scenarios. A Recovery Plan (last updated 2004) has been drawn up by the US National Marine Fisheries Service (NMFS); it considers all known threats, but does not specify a mechanism for assessing and addressing cumulative impacts.

"Southern resident" killer whales in the eastern North Pacific.
The population has been well-studied for 30 years; all living individuals are believed known, as are most individuals that have died since research began. The reproductive history and parentage of individuals is also known. The population inhabits the inshore waterways of Washington State and southern British Columbia from spring to autumn, and ventures as far as central California in winter.

The social structure and feeding habits are well studied. It appears to be genetically isolated from other killer whale populations. Threats include interactions with commercial shipping, ferries, whale watching, research and recreational vessels (noise, disturbance and collisions); reduction of food resources (Chinook salmon); and contaminants (including PCBs and PBDEs). The population is also potentially vulnerable to major oil spills in its feeding habitat should these occur. A Recovery Plan under the US MMPA and a Recovery Strategy under the Canadian Species at Risk Act (SARA) were each published in 2008.

The anthropogenic stressors that potentially affect each of these populations are listed in Tables 1 and 2 along with the population parameters that are liable to be affected by each stressor.

The results of the two case studies can be both of direct use in the conservation of the studied populations, and also contribute to the development of techniques and impact reduction targets for application to less well studied populations and locations. The success of the case studies will depend critically on the support and contribution of those experts most closely involved in the study and management of these populations.

Further case studies can be added later. The application of these approaches to Arctic species such as bowhead whales and beluga will represent a particular challenge, as we may see not merely incremental changes relative to the previous state of the environment, but a radically new habitat. The retreat of sea ice may open up the Arctic to greatly increased levels of shipping, seismic surveys and industrial activity with associated noise and other impacts.

Stressor	Survivorship	Feeding effectiveness / growth	Calving rate / interval	Distribution changes
Ship Strikes	–	–?	0	0
Whale Watching / Scientists	0	–?	0	0
Entrapment and Entanglement in Fishing Gear	–	–	0	0
Habitat Degradation	0	0	0	-?
Noise	0	–	–?	-?
Contaminants	–?	0	–?	0
Underwater Explosives	–	0	0	0
Climate and Ecosystem Change	+/–	+/–	+/–?	+/–?
Commercial Exploitation	0	0	0	0
Genetic / Inbreeding Effects	–?	0	–?	0

Table 1. Threats facing North Atlantic right whales. Stressors were originally drawn from the Recovery Plan for the North Atlantic Right Whale (NMFS 2005). Table entries reflect initial thoughts about the direction of impact that participants believed to be represented in the literature at the workshop: - = negative effect; + = positive effect; 0 = no significant effect. ? = indicates a limited availability of precise data in this particular population or species, although the participants still believe an effect is likely to be present.

Stressor	Survivorship	Feeding effectiveness / growth	Calving rate / interval	Distribution changes
Overfishing / Habitat (inc. hatcheries)	–	–	–	–
Environmental Contaminants	–	–?	–	0
Whale Watching	–?	–	0	–?
Oil Spills	–	–?	–	–?
Alternative Energy Projects	–?	?	0	?
Disease	–?	?	–?	0
Research	–?	–?	0	0
Social Structure Issues	– (c)	–	–	–
Other Noise	–?	–	–?	–?
Genetic / Inbreeding Effects	–?	0	–?	0

Table 2. Threats facing Southern Resident killer whales. Stressors were originally drawn from the Recovery Plan for Southern Resident Killer Whales (NMFS 2008). Table entries reflect initial thoughts about the direction of impact that participants believed to be represented in the literature at the workshop: - = negative effect; + = positive effect; 0 = no significant effect. ? = indicates a limited availability of precise data in this particular population or species, although the participants still believe an effect is likely to be present. (c) indicates the effect is thought to be primarily a concern for calves.

8. References

NMFS (U.S. National Marine Fisheries Service) 2005. Recovery Plan for the North Atlantic Right Whale (*Eubalaena glacialis*). National Marine Fisheries Service. Silver Spring, Maryland. Available at: http://www.nmfs.noaa.gov/pr/pdfs/recovery/whale_right_northatlantic.pdf.

NMFS (U.S. National Marine Fisheries Service) 2008. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service, Northwest Region, Seattle, Washington. Available at: http://www.nmfs.noaa.gov/pr/pdfs/recovery/whale_killer.pdf.

Wright, A.J., Bode, M., Loseto, L., Ramasco, J.J., Munns, W., Deak, T. & Kroeker, K.J. 2009. A Model of Cumulative Impacts on an Individual Marine Mammal. *Report of the Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals: From Ideas to Action.*

Acknowledgements: This paper arose from the Workshop on Cumulative Impacts/ Effects of Anthropogenic Stressors on Marine Mammals: From Ideas to Action, 26-29 August, 2009. It could not have been written without either the generous support of the sponsor, Okeanos – Foundation for the Sea, or the contributions from the many participants, both at the meeting and through reviews of early versions. The views expressed in this paper are those of the authors alone and do not represent those of any institution or agency, governmental or otherwise, that they may be affiliated with.

A Model of Cumulative Impacts on an Individual Marine Mammal

Andrew J. Wright, Michael Bode, Lisa Loseto, Jose J. Ramasco,
Wayne Munns, Terrence Deak, Kristy Jean Kroeker

1. Introduction

Marine mammal species confront a set of stressors[1] that may be tolerable in isolation, but cumulatively impact population viability (i.e., through effects on survival and reproduction). These stressors range from persistent organic pollutants and bycatch, to recently acknowledged acoustic disturbances. While conservation concerns and regulatory authority are manifested primarily at the population scale, our understanding of the impacts of particular stressors is predominantly described at an individual level – a scale that has proven more amenable to experimentation. An individual-based population model can act as a bridge between our understanding of individuals and our interest in population demographics. A small expert group of workshop participants began to develop a model of the cumulative impacts of anthropogenic activities on individual marine mammals. This model describes various stressors that may affect the survival and reproduction of an individual, focusing particularly on the potential interactions between such stressors. Even at this early, conceptual stage, it could help inform development of more realistic population models for assessing the impacts of multiple stressors on populations, as well as simulate effects of different intervention measures.

2. Model development

The group began this exercise by listing the stressors and impacted biological processes that would eventually become the basic elements of an individual marine mammal cumulative impact model. First, we identified ten serious ***stressors*** marine mammals face (the blue boxes in Fig. 1). Then, we created a list of stressor-associated ***health effects*** to marine mammals for each of these stressors, which included both physiological and behavioral impacts/effects (the health effects for those stressors that remain in the model are listed in Table 1). Next, we grouped the comprehensive list of consequences into nine larger categories that we called ***individual attributes***[2] (the red ovals in Fig. 1). The individual attributes are each representative of a broad health state, function or process within an individual. For example, we considered a ship-strike injury to be a form of "Physical Injury" – a change that makes daily life more difficult in general. A set of other impacts, including acoustic trauma and non-lethal predator attacks, were also grouped under the umbrella, "Physical Injury".[3]

---

[1] 'Stressor,' as it is used here, is not intended to insinuate that the anthropogenic activity or natural (although anthropogenically altered) challenge is producing a full stress response within the individual. It only indicates that the individual is presented with that particular challenge.

[2] It should be noted that 'Climate Change' and 'Habitat Loss' were originally included in the model as additional stressors, but we realized that these mostly impact marine mammals – and particularly cetaceans, such as our two likely case study populations (see Cooke et al., 2009) – through other mechanisms that were included here (e.g., 'Reduction in Prey Abundance'). They were therefore removed from the list in the interests of simplicity. Similarly, 'Death' was originally included as a consequence of several of the stressors, but was removed as it is instead an end-point for the model and can be thus included in any of the processes or attributes.

[3] We acknowledge that some effects are not included in this model. We have attempted to catch all the major influences, but fully expect the model to develop further as we begin to incorporate numerical values. For example, we have not included any ways that individual attributes might feed back to influence the way that stressors might affect them (e.g., when animals metabolize their fat stores, they may release contaminants locked within those stores into the blood stream, essentially increasing their dosage). Similarly, possible multi-generational impacts are not included in this conceptual model, such as the direct influence of a reduction in time spent parenting, perhaps to increase time available for foraging, on the stress reactivity of an affected offspring. However, in this case, the multi-generational effects go beyond the capabilities of this conceptual model and would need to be included in wider individual-based population models.

After substantial discussion, it was decided that the health impacts of the stressors to be included in the conceptual model would be restricted at this time to readily identifiable changes in the physiology and behavior of marine mammals that have been reported in the literature. Problems with measurement of traditional physiological metrics of the stress response (corticosteroids, catecholamines, heart rate, blood pressure, etc) or attribution of psychological distress in marine mammals mean that such impacts have not been studied in detail to date and therefore these effects do not meet the reported criteria. With this in mind, the focus group recognized the two key components of individual consequences that are not represented in the model below, although we believe that there is enough data available in other species that they could be included through the use of scientifically supported assumptions. First, there are a variety of stress-related pathologies (increased general anxiety, post-traumatic stress, etc) that probably have a significant impact on how future stressors are evaluated by, but that cannot be adequately quantified in, marine mammals. Second, prolonged exposure to substantial stressors is often accompanied by periods of recuperation, during which an organism's behavior is severely disrupted from normal, and that are crucial in driving physiological (and potentially psychological) recovery from prior insults. Though omission of these two factors represents limitations to the conceptual model, it seems imperative to incorporate these concepts in future model development.

Stressor	Health Effects
Bycatch	Injury and potentially death.
Contaminants: Hg	Neurotoxic, leading to issues with learning, vision, motor skills. (NOTE: several forms capable of bioaccumulation and biomagnifications rendering high trophic level and long lived species at greater risk)
Contaminants: Non-PBTs*	Disorientation through narcotic effects, liver toxicity and death. (NOTE: include industrial and urban waste such as oil spills, sewage, pharmaceuticals that are typically metabolized by vertebrates yet may compromise food quality and quantity)
Contaminants: PBTs*	Disruption of endocrine (hypothal, thyroid), immune (possibly also growth) and reproductive systems (hormone disruption via xeno-estrogens). (NOTE PBTs are also carcinogenic and might also alter food availability if it makes prey sick. The quality of this food will also be inherently compromised).
Continuous (chronic) sound	Hearing loss (disorientation and possibly injury?), Reduction in energy budget, prey availability and reproduction through masking, obscuring, coping and avoidance. Noise from ships has been both suggested (by acoustical studies) to increase and decrease the risk of ship strikes.
Impulsive / tonal (acute) noise	Increase in harassment and disturbance (including alert & stress response), hearing damage (disorientation and possibly injury), potentially non-aural injury and death. Also displacement from habitat is possible (for them or their prey), which can reduce prey availability. May also increase bycatch
Increased Predation	Increase in harassment and disturbance (including alert & stress response), injury, and death
Pathogens	(Potentially increased as a consequence of climate change.) Decrease in reproduction and energy budget, a compromised immune system, injury, and death
Reduced prey availability	(Including through habitat loss and/or increase competition, perhaps as a result of climate change.) Decrease in energy budget
Ship strike	Injury and potentially death.

Table 1. Stressors and health effects. *PBT = persistent, bioaccumulative, toxic.

The final step was to propose connections between these 19 “nodes” (10 stressors and 9 individual attributes) through a flow diagram. Links drawn with red arrows reflect the immediate or direct consequences of stressors for an individual (see Table 1.). For example, increases in the numbers of predators lead to a heightened risk of harassment or injury to individuals (and also death), prompting red arrows linking the stressor “Increased Predation” with the individual attributes of “Physical Injury” and “Harassment / Disturbance”.

Causal links between the various stressors themselves were designated using blue arrows. For example, “Continuous (Chronic) Noise” may lead to an effective reduction in prey availability since it can render hunting more difficult (“Reduction in Prey Availability”). Analogously, causal links between the individual attributes, where impacts on one aspect of an individual’s health can, in turn, have important consequences on another, were included using green arrows. For example, “Physical Injury” will likely lead to a reduction in food intake, decreasing an individual’s “Energy Budget” (i.e., the energy available to the individual for movement, growth and reproduction, etc.), in the same way, perhaps, as a reduction in prey availability. This conceptual model (Fig. 1) was ultimately presented to all Workshop participants at the meeting. Although it has been revised slightly since, all participants have been able to review the changes.

Participants believe that the model offers a new way to think about the possible combinations of stressors to an individual that can produce synergistic or antagonistic consequences. They also agreed that the model might form the basis of an individual-based cumulative impact model for populations of marine mammals.

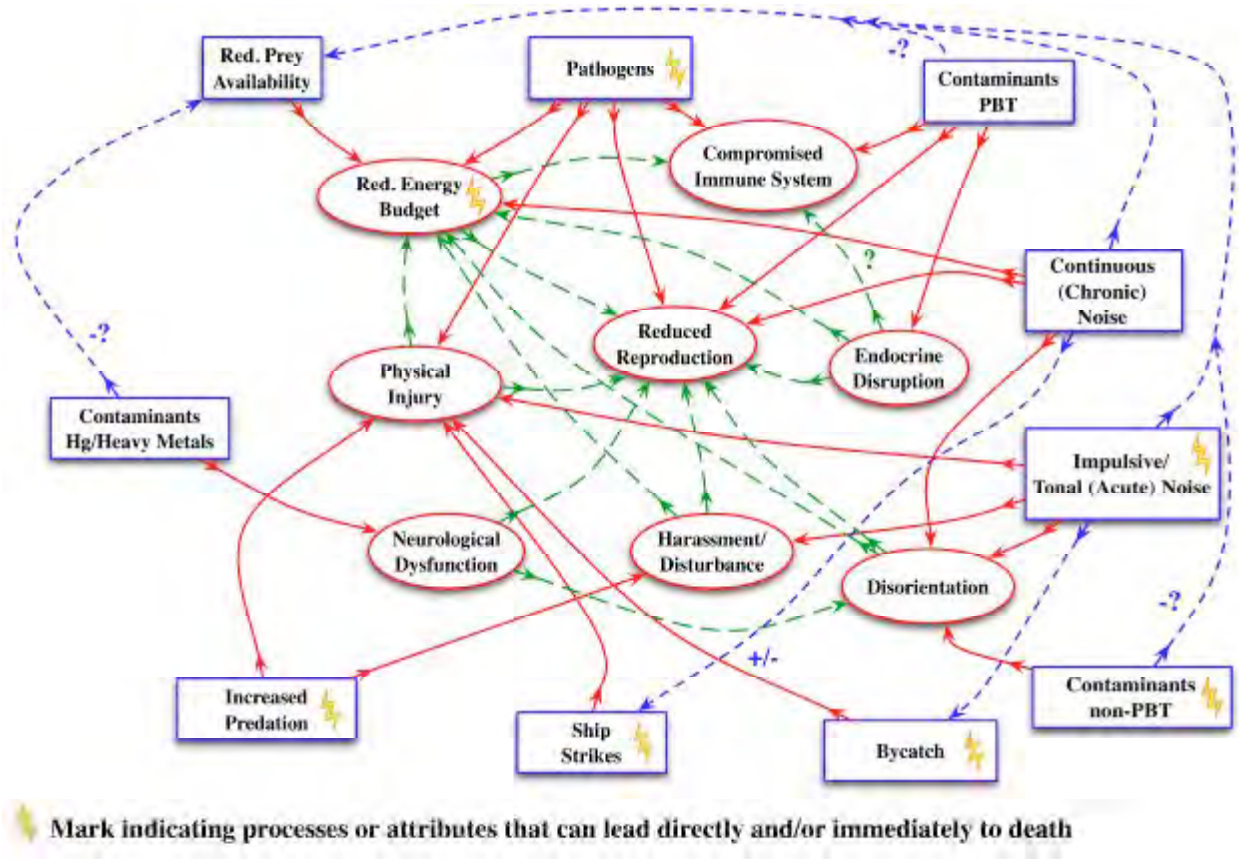


Figure 1. The Cumulative Impacts Conceptual Model

3. Next steps

The original members of the small group would like to develop this model further as follows:

1) The model's nodes (i.e., stressors and individual attributes) and links (i.e., paths of action and interaction) will be revised and refined to improve the model's value as a conceptual tool for the consideration of cumulative impacts.
2) Numerical values (or ranges) will be assigned to all the various model components as far as possible.
3) Expert opinion will be combined with a (species specific) sensitivity analysis to determine at least the appropriate level of magnitude for values to be assigned to outstanding components.
4) The products of this additive model will be compared with the data available on synergistic, additive and antagonistic interactions between stressors, to determine the reliability of the model and to update links as appropriate.
5) The model itself (even conceptually) could then be used by managers to identify probable cumulative impacts as part of their management of multiple stressors to a species or population.
6) The model, if suitably reliable, might become part of the wider effort by Workshop participants to investigate cumulative impacts on certain data-rich case study populations of marine mammals through the development and analysis of an individual-based model. These case studies will then be used to guide policy makers and (potentially) develop more generalized models that can be applied more widely. Such models may need to be focused mostly on determining when cumulative exposures can become problematic for a population due to the lack of available appropriate data for the majority of marine mammal species.

4. References

Cooke, J., Bode, M., Clark, C., Crowder, L., Green, J., Loseto, L., Mangel, M., Munns, W., Ramasco, J., Reeves, R., Satterthwaite, W.H., Suydam, R., Taylor, B., Weilgart, L., Wright, A.J. 2009 Modeling the Population Effects of Cumulative Impacts. *Report of the Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals: From Ideas to Action.*

Acknowledgements: This paper arose from the Workshop on Cumulative Impacts/ Effects of Anthropogenic Stressors on Marine Mammals: From Ideas to Action, 26-29 August, 2009. It could not have been written without either the generous support of the sponsor, Okeanos – Foundation for the Sea, or the contributions from the many participants, both at the meeting and through reviews of early versions. The views expressed in this paper are those of the authors alone and do not represent those of any institution or agency, governmental or otherwise, that they may be affiliated with.

Participants

1. Participants (Chair, then in alphabetical order)

- Chair – Leila Hatch, Ph.D., Marine Ecologist, Stellwagen Bank National Marine Sanctuary, U.S. National Ocean Service, National Oceanic and Atmospheric Administration, 175 Edward Foster Road, Scituate, MA, 02066, USA.
- Michael Bode, Ph.D., School of Botany, University of Melbourne,Victoria 3010, Australia.
- Peter Brewer, Ph.D., Monterey Bay Aquarium Research Institute, 7700 Sandholdt Road, Moss Landing, CA 95039, USA.
- Christopher W. Clark, Ph.D., Director Bioacoustics Research Program, Cornell Lab of Ornithology, Senior Scientist, Department of Neurobiology and Behavior, Cornell University, 159 Sapsucker Woods Rd., Ithaca, NY 14850 USA.
- Justin Cooke, Ph.D., Centre for Ecosystem Management Studies, Höllenbergstr. 7, 79312 Windenreute, Germany.
- Larry B. Crowder, Ph.D., Stephen Toth Professor of Marine Biology, Duke University Marine Lab, Duke Center for Marine Conservation, 135 Duke Marine Lab Road, Beaufort, NC 28516, USA.
- Terrence Deak, Ph.D., Associate Professor, Behavioral Neuroscience Program, Department of Psychology, SUNY-Binghamton, Binghamton, NY 13902-6000, USA.
- Christine Erbe, Ph.D., JASCO Applied Sciences, Brisbane Technology Park, PO Box 4037, Eight Mile Plains, Qld 4113, Australia.
- Kurt Fristrup, Ph.D., U.S. National Parks Service, Natural Sounds Program, 1201 Oakridge Drive, Suite 100, Fort Collins, CO 80525, USA.
- Jeffrey E. Green, M.Sc., R.P. Biol., P. Biol., Senior Principal, Environmental Management, Stantec, 4370 Dominion Street 5th Floor, Burnaby, BC, V5G 4L7, Canada.
- Lorne Greig, M.Sc., Senior Systems Ecologist, ESSA Technologies Ltd., 77 Angelica Avenue, Richmond Hill, ON L4S 2C9, Canada.
- Jolie Harrison, M.Sc., U.S. National Marine Fisheries Service, Office of Protected Resources, 1315 East-West Highway, SSMC3, Silver Spring, Maryland 20910, USA.
- John Hildebrand, Ph.D., Professor of Oceanography, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA 92093-0205, USA.
- Craig Johnson, U.S. National Marine Fisheries Service, Office of Protected Resources, 1315 East-West Highway, SSMC3, Silver Spring, Maryland 20910, USA.
- Carrie Kappel, Ph.D., Assistant Project Scientist, National Center for Ecological Analysis and Synthesis, University of California, Santa Barbara, 735 State Street, Suite 300, Santa Barbara, CA 93101, USA.
- Kristy J. Kroeker, Ph.D candidate: Micheli Lab, Hopkins Marine Station, Stanford University, 100 Oceanview Blvd., Pacific Grove, CA, 93950.
- Lisa L Loseto, Ph.D., NSERC Post Doctoral Fellow, School of Earth and Ocean Sciences, University of Victoria, Victoria BC, V8W 3V6, Canada.

- Marc Mangel, Ph.D., Distinguished Professor of Mathematical Biology; Director, Center for Stock Assessment Research, Department Applied Mathematics & Statistics, The Jack Baskin School of Engineering, University of California, Santa Cruz, CA 95064, USA.
    - Assisted/replaced by William H. Satterthwaite, Ph.D., Postdoctoral Researcher, Center for Stock Assessment Research, Department Applied Mathematics & Statistics, The Jack Baskin School of Engineering, University of California, Santa Cruz, CA 95064, USA.
- Wayne Munns, Ph.D., U.S. Environmental Protection Agency, Office of Research and Development, Narragansett, RI 02882
- Jose Javier Ramasco, Ph.D., ISI Foundation, Viale S. Severo 65, 10133 Torino, Italy.
- Randall R. Reeves, Ph.D., Chairman, IUCN/SSC Cetacean Specialist Group; Member of Committee of Scientific Advisers, Marine Mammal Commission; 27 Chandler Lane, Hudson, Quebec, J0P 1H0, Canada.
- Robert Suydam, Ph.D., P.O. Box 1132, Barrow, AK 99723, USA.
- Barbara Taylor, Ph.D., Southwest Fisheries Science Center, NOAA Fisheries Service, 3333 N. Torrey Pines Court, La Jolla, CA 92307-1022, USA.
- Lindy Weilgart, Ph.D., Department of Biology, 1355 Oxford St., Dalhousie University, Halifax, Nova Scotia B3H 4J1, Canada.

Okeanos had invited an environmental economist to attend (and present in Session 9, see Abstracts below), but they had to pull out just one month before the workshop. We were not able to find a replacement at such short notice. We did not receive an abstract and so participants were not able to consider such things within their deliberations. Instead, we simply acknowledge that this area may have methodology that could be adapted for application to cumulative impact/effect assessment.

Similarly, Okeanos invited Fisheries and Oceans (DFO), Canada, to send a representative from their regulatory offices, given the discussions of current methods for assessing cumulative impacts and the anticipated focus on the Arctic. Our invitation was ultimately declined.

Presentation Abstracts

1. Introduction

1.1 Including noise in evaluating the cumulative impacts of human activities on marine mammal species: a roadmap to the Okeanos workshop

Leila T. Hatch
Marine Ecologist, NOAA/NOS Gerry E. Studds Stellwagen Bank National Marine Sanctuary, 175 Edward Foster Road, Scituate, MA 02066 USA

Human activities generate sound in the marine environment for explicit purposes (e.g., mapping or exploration), and as an incidental byproduct of industrial activities (e.g., construction or transportation). The legislative basis for most undersea noise regulation in US waters focuses on the protection and recovery of particular species (e.g. the Marine Mammal Protection Act [MMPA] and Endangered Species Act [ESA]). The regulatory processes that implement this legislation (authorization to injure or harass marine mammals and evaluation of noise impacts to endangered species) rely heavily on estimating the number of individuals that will be exposed to specified noise levels. These estimates incorporate knowledge or assumptions regarding the sound source characteristics, propagation conditions, and the location and movements of individual animals. Such analyses face significant challenges in accounting for cumulative impacts to individuals and populations over temporal and spatial scales pertinent to most protected or listed marine animals and many types of underwater noise (Hatch and Fristrup in press). In addition, software packages designed primarily to calculate accrued exposure to focal animals do not reflect relationships between different focal species (such as different whale species), between focal and non-focal species (such as marine mammals and their prey) or other indirect effects of noise exposure resulting from interspecific interactions (*ibid*). Finally, these modeling techniques do not address possible synergism or additive effects experienced by individuals exposed to noise as well as other environmental stressors. Thus, impact assessments based on these analyses are often insufficient to meet mandates imposed by the ESA and MMPA, as well as those of the National Environmental Policy Act which require the National Oceanic and Atmospheric Administration (NOAA) to take into account cumulative impacts to protected or listed species and their habitats when authorizing acoustic harassment and when evaluating noise impacts.

There have been significant efforts over the past five years to develop more comprehensive analytical frameworks for evaluating noise impacts to marine mammals. In 2004, a committee convened by the National Research Council of the US National Academies held a public workshop to discuss methodologies for determining when noise causes biologically significant effects to marine mammals (NRC 2005). Workshop participation helped formulate a conceptual model, called the Population Consequences of Acoustic Disturbance [PCAD] model, to trace acoustic disturbance through the life history of a marine mammal and then to determine the consequences for the population (*ibid*). Also in 2004, the International Whaling Commission Scientific Committee's Workshop on Habitat Degradation developed a general framework for modeling the links between environmental stressors that degrade cetacean habitat (including noise) and population effects (IWC 2006, Figure 3). New analytical methodologies for estimating the cumulative exposure of marine animals to noise have recently been applied to address a variety of mitigation and/or monitoring contexts (see Erbe & King 2009, Clark et al. in press, NOAA 2009).

Recommendations to expand analytical frameworks to better assess cumulative noise impacts have often stressed the need for management frameworks to expand in parallel. The concept of Potential Biological Removal (PBR) (Taylor et al. 2000) as developed by scientists at NOAA Fisheries, and the concept of the revised management procedure (RMS) (Cooke 1994) as developed by scientists

associated with the International Whaling Commission both provide methods for integrating scientific uncertainty into marine mammal management decisions. To apply the PBR concept to address cumulative impacts to populations and species more effectively, the 2005 NRC committee recommended including all sources of mortality, injury and behavioral disturbance (including noise) in threshold determinations, rather than focusing on fishing-associated impacts in isolation (NRC 2005). Similar recommendations have been made to ensure that RMS threshold extraction levels remain conservative in the face of significant uncertainty resulting from complex multi-stressor and multi-species interactions (IWC 2006).

Finally, area-based management tools have been suggested for the purpose of assessing and addressing human-induced underwater noise more holistically in places designated to be of national concern (Hatch and Fristrup in press). By focusing on management of all living and non-living resources within a local area, marine protected areas (MPAs), such as US National Marine Sanctuaries, can serve as "sentinel sites" for evaluating acoustic impacts on an ecosystem rather than species-specific basis. As many nations consider an expanded role for marine spatial planning to address increasing urbanization in coastal and outer shelf waters, MPAs are poised to play a valuable role in developing tools to evaluate the impacts of noise and other human-induced stressors within a diversity of local marine environments.

References

Clark, C.W., Ellison, W.T., Southall, B. L., Hatch, L.T., Van Parijs, S.M., Frankel, A., and Ponirakis, D. in press. Acoustic Masking in Marine Ecosystems: Intuitions, Analysis, and Implications. *Mar Ecol Prog Ser*

Cooke, J.G. (1994) The management of whaling. *Aquatic Mammalogy* 20: 129-135

Erbe, C. and King, A.R. (2009) Modeling cumulative sound exposure around seismic surveys. *J Acoust Soc Am* 125(4): 2443-2451

Hatch, L.T. and Fristrup, K.M. (in press) No barrier at the boundaries: implementing regional frameworks for noise management in protected natural areas. *Mar Ecol Prog Ser*

International Whaling Commission (IWC) (2006) Report of the IWC Scientific Committee Workshop on Habitat Degradation. *J Cetacean Res Manage* 8 (Suppl): 313-335

National Research Council of the US National Academies (NRC) (2005) Marine mammal populations and ocean noise: determining when ocean noise causes biologically significant effects. National Academy Press, Washington, DC

National Oceanic and Atmospheric Administration (NOAA) (2009) Programmatic biological opinion on U.S. Navy training activities on the Northeast, Virginia Capes, Cherry Point, and Jacksonville Range Complexes for the period of June 2009 through June 2014. National Marine Fisheries Service, Office of Protected Resources, Endangered Species Division; Silver Spring, MD

Taylor, B.L., Wade, P.R., DeMaster, D.P. and Barlow, J. (2000) Incorporating uncertainty into management models for marine mammals. *Con Bio* 14: 1243-1252

2. Marine mammals and noise: A review of available information on impacts of noise on marine mammals

2.1 An overview of the importance of sound for marine mammals and the variety of anthropogenic underwater noise sources

Lindy Weilgart

Marine mammals, particularly cetaceans (dolphins, porpoises, and whales), use sound for all aspects of their life, including reproduction, feeding, communication, navigation, hazard avoidance, and

otherwise sensing their environment. Hearing is their primary sense, as sound travels very efficiently underwater (hundreds of kilometers), whereas vision is limited to only tens of meters. Some cetaceans use active biosonar, emitting sound pulses to "see" with sound, but all marine mammals probably depend to a large degree on listening (passive detection) for the sounds their prey, predators, conspecifics, and environment make. Sometimes sounds of great importance can be very faint, so that even small increases in underwater noise can make the difference between detecting a predator, prey, or navigational hazard in time, or not. Some cetaceans are primarily solitary and widely scattered. In blue and fin whales, for instance, females probably must rely on finding mates by the loud, low frequency sounds males make. Such calls can theoretically travel almost across ocean basins, at least in the absence of appreciable human-made noise. Cetacean vocalizations are thought to be used for purposes such as to coordinate movements and maintain contact between group members, to repel mating competitors and attract mates, to identify group membership, etc. Mating songs probably also allow females to assess the quality of potential mates. Echoes from the ice may help whales found in polar waters navigate through open leads safely. Similarly, whales likely use acoustic cues, such as echoes from ocean bottom features or surf noise, to find their way during long migrations. It is unknown to what degree sound quality is important, or whether in some circumstances it is enough merely to detect the presence or absence of a sound. Undoubtedly, though, some information which may be critical, is lost in conditions of higher underwater noise. Thus, it is safe to assume that anthropogenic ocean noise is a threat to marine mammals, especially cetaceans.

Manmade underwater noise is principally caused by shipping, seismic surveys by the petroleum industry to find undersea deposits of oil and gas, and naval sonar. Other sources include underwater explosions, construction, drilling, pile driving, icebreakers, oceanographic experiments, acoustic harassment devices (e.g. to repel seals from aquaculture facilities), and recreational boating. These noise sources vary in characteristics such as loudness, pitch, duration, rise times, directionality, duty cycle, etc. Cetaceans also vary in how they react to even the same noise source, depending on the species, age, sex, prior experience, and context. Noise impacts may be long- or short-term, and could primarily affect the individual or population, although these distinctions are very difficult to discern in cetaceans, given how little is known of most populations. Acute noise impacts are those where noise exposure quickly results in fatal strandings or deaths at sea, or immediate hearing damage. Chronic noise impacts include "masking" or the obscuring of important signals, such as from the incessant hum of shipping traffic. Hearing damage may also occur from chronic underwater noise. Both acute and chronic impacts can be serious, and can cause population-level effects.

2.2 The potential impacts from chronic noise and methods for measuring the potential long-term impacts from multiple non-pulsed sources, including assessment of variability in noise fields over space and time

Christopher W. Clark

In the domain of marine mammals, this topic, although seemingly intuitive and obvious, is not well defined or constrained by standard terminology, methodologies, or knowledge. There is little to no precedent as to the scientific processes for quantifying and evaluating "potential impacts from chronic noise." Therefore, such discussions often begin with an imbalance of attitudes. expectations, and expertise, and, most importantly, a lack of consensus as to a way forward. Notice that the word potential has been inserted to qualify the word impacts. Recognize that there is no clear scientific definition of "non-pulsed sources." Understand that measuring and mapping noise over scales appropriate for marine mammals is extraordinarily difficult and has rarely been attempted. Accept the fact that many of you reading this do not have hands-on experience studying whales or measuring sound underwater. Thus, it is important to set one's frame of mind with a fair amount of

cognitive flexibility and begin with as much of an open mind as possible when it comes to thinking about chronic noise and marine mammals. We are at the beginning of a journey with only a rather crude map and without necessarily a consensus as to where exactly we're going, why we're going there, how we're going to get there and what we're going to find once we arrive. But the river is flowing, we're in it and so we must prepare for what is happening and for what lies ahead.

In this presentation I will focus on the issue of "potential impacts from chronic noise" as it relates to free-ranging, baleen whales because I believe this is the group likely at greatest potential risk from chronic exposure from anthropogenic sound. My working mode is to use the biology of the animals to set specifications and to constrain uncertainty. At the same time I try to establish a paradigm and an algorithm that can be applied to other groups of marine mammals. Baleen whales are extraordinarily well adapted for listening to and producing sounds in the low-frequency band (<1000Hz). Therefore the spatial and temporal scales of concern are as great as many tens of thousands of square miles and many decades. "Non-pulsed sources" are those sources that generate sound for at least as long as the whales' own sounds (e.g., 1-2 s) or the sounds of biological importance (e.g., predators, ocean upwelling).

One of the most likely chronic impacts from noise, and the one I will focus on here, is that of acoustic masking of communication sounds, first articulated by Roger Payne and Doug Webb in 1971 for blue and fin whales. Communication masking is the loss of communication space as a result of sound added to the ambient noise environment. Communication space is the space over which animals communicate, and the communication masking metric is referenced to the communication space under ocean noise conditions prior to human activities that generate noise in the ocean, referred to as ancient ambient. Vessel noise is the primary anthropogenic source of sound added to the ocean's low-frequency environment, but other sources include those from such things as seismic exploration, construction and active sonars.

Here I present a model, informed by empirical data, to quantify the effect of vessel noise on acoustic communication space for three species of baleen whales: fin, humpback and right whales. Acoustic data are from long-term acoustic monitoring systems sampling the low-frequency band throughout ocean areas of 400 – 10,000 nmi2 for periods of months to years. Resultant acoustic data were analyzed to map, quantify and describe the spatio-temporal variability of the acoustic habitat over ecologically meaningful scales for the three species. Species-specific 3rd octave frequency bands were used for right whale contact calls and fin and humpback whale songs. Ship GIS movements and source characteristics were documented using the U.S. Coast Guard's Automatic Information System (AIS) and seafloor acoustic recorders, respectively. Results quantify the extent to which multiple sources of sound in the ocean cumulatively influence the ambient noise environment throughout an area within which and over time periods when whales are known to be acoustically active. By this procedure, we define acoustic communication space as part of both an individual animal's and a population's ecological habitat. By altering this communication space, anthropogenic activities have the potential to impact such basic biological activities as mating, foraging, or migrating. In some habitats with high levels of vessel noise, the predicted area over which animals can communicate is routinely reduced to a small proportion (< 20%) of what it would be under ancient ambient conditions. When considered from a large-scale and behavioral ecology perspective, reduction in acoustic habitat, as measured in terms of the proportional loss of communication space, likely represents a significant cost for species to which acoustic communication is biological critical.

2.3 Acute impacts of noise and a summary of methods currently applied to sum impacts from repeated exposure to impulsive sources

John Hildebrand
Scripps Institution of Oceanography, University of California San Diego,
La Jolla, CA 92037

Decibels are the standard shorthand for describing acoustic intensity and sound pressure level, but may lead to misunderstanding when applied as bioacoustic metrics. Acoustic power and source transmission energy are alternate metrics with intuitive appeal. Acoustic power, calculated from the acoustic intensity, multiplied by the emitted solid angle, yields units of Watts. Likewise, the energy per source transmission, given by multiplying acoustic power by the duration of the transmission, yields units of Joules. For continuous (or quasi-continuous) signals, the standard procedure is to measure the root-mean-square (RMS) of the signal. However, this presents problems for short duration (impulsive) signals where the duration of the signal being measured is an important parameter. In these cases it may be more appropriate to measure the peak-to-peak signal, rather than RMS. Bandwidth is another important component of how the signal is described, typically in a narrow-band for ambient noise and broad-band for discrete sources. The characteristics of acute anthropogenic noise sources in terms of these metrics will be discussed.

3. Interactions of noise and other threats to marine mammals

3.1 Cumulative and synergistic impacts of natural and anthropogenic stressors: lessons from the lab

Terrence Deak,
Behavioral Neuroscience Program, Department of Psychology,
State University of New York at Binghamton.

All species face a diverse range of threats that stem from their ecological niche. These threats most commonly arise in the form of natural stressors such as predator exposure, food/nutrient deprivation, social stress associated with the development and/or maintenance of social hierarchies and territoriality. For the most part, species-specific and threat-specific strategies have evolved at both the physiological and behavioral level to minimize the impact of these natural threats, thereby optimizing survival and reproduction. Industrialization of human society over the past 200 years, however, has brought forth an entirely new set of threats, referred to as anthropogenic stressors, which expand both the quantity and quality of challenges that wildlife face in their daily life. Examples of some anthropogenic stressors include (but are not limited to) extreme noise and vibration, habitat destruction and the accompanying loss of food/shelter, exposure to chemical pollutants, toxins and toxicants. The influence of anthropogenic stressors is felt by all species, yet nowhere are these effects more prominent than in marine mammals. Though there is some agreement that the uptick in anthropogenic stressors has led to rapid and deliberate adaptation among affected species, the cumulative and synergistic impact of chronic stress exposure (arising from both natural and anthropogenic sources) on the physiology and behavior of wildlife can be difficult, if not impossible, to predict.

Recent advances in stress physiology may provide significant insight into the expected outcomes of anthropogenic stressors. The two main stress responsive systems are the sympathetic nervous system (SNS) and the Hypothalamic-Pituitary-Adrenal (HPA) axis. These classic stress-responsive systems have been highly conserved across vertebrate species and in many ways represent a general response to nearly all threats. More recent advances suggest that activation of inflammatory signaling pathways in response to stress challenges play a key role in orchestration of the stress response, and provide a crucial link between stressor exposure and the development of stress-related

pathology. Importantly, stress-dependent activation of inflammatory signaling pathways (i) occurs across a wide range of endocrine glands and bodily organs; (ii) does not depend on the presence of any apparent antigen or infection; and (iii) may occur as a final point of convergence for intense, or categorically distinct, stress challenges. These findings may implicate inflammatory signaling factors as more appropriate biomarkers for stress-related pathology (than the classic stress responsive systems), and identify inflammation as a potential target for ameliorating adverse health consequences of stressor exposure. Given the role that inflammatory signaling pathways play coordination of host immune responses to pathogens (bacteria, viruses, parasites, etc) and foreign antigens (chemical toxicants, pullutants, etc), the likelihood of synergistic – or competitive – interactions between true immunological challenges and psychological threats abound. Indeed, such interactions are well-precedented in the biomedical literature, yet the form of such interactions (sensitization, cross-sensitization, etc) remain difficult to predict. In this talk, we will provide a theoretical framework that may be useful for predicting adverse consequences of stress.

3.2 Multi-stressor interactions in the Arctic

Lisa L. Loseto [1,2], and Peter S. Ross [2]
[1] *School of Earth and Ocean Sciences, University of Victoria, Victoria, BC Canada*
[2] *Institute of Ocean Sciences, Fisheries & Oceans Canada, Sidney, BC Canada*

Arctic marine mammals have adapted to a marine environment in which sea ice dominates the seascape and its food web. Some Arctic marine mammals are ice-obligate and require sea ice for survival (e.g. ringed seals), while others feed in the seasonal productive ice-edge zones. In this way, the climate change-related loss of sea ice poses a real and dramatic risk to such marine mammals. Change in sea ice dynamics will directly impact marine mammals by altering their habitat, as well as have indirect effects to food web productivity that may alter prey quality and quantity. A reduction in sea ice will also have a multitude of indirect impacts on other stressors that already exist in the Arctic marine environment. Arctic marine mammals have been exposed to environmental contaminants and disturbance related to human/industrial activities in the Arctic and elsewhere. Although the Arctic is far removed from industrial and urban pollution typical of mid latitudes; contaminant levels in Arctic marine mammals are relatively high due to the ability of some contaminants to undergo long range transport. Of particular concern are persistent organic pollutants (POPs) that include the endocrine-disrupting PCBs, and the metal mercury, a neurotoxin. Local sources of contaminants such as hydrocarbons may soon become a concern with increased industrial activity in the north. The opening of the Northwest Passage will attract shipping vessels as it offers a shorter route between the Atlantic and Pacific than through the Panama Canal. This will increase noise and disturbance in the water column, and may cause habitat displacement if (when) ice breakers are used. Shipping activity will also increase with the oil and gas exploration, development and advancement throughout the North. Oil and gas exploration techniques employ acoustic means, specifically seismic exploration (e.g. dynamite, air guns) to locate hydrocarbon sources. Given the anticipated increase in demand of oil and gas, and the increased accessibility to the Arctic, there is little doubt that the Arctic will become busier, noisier, and more contaminated. The extent to which these stressors represent a real threat to Arctic marine mammal populations will depend in large on our ability to understand habitat needs in a changing world. Human/industrial activity, climate change and contaminant exposure have synergies in occurrence and prevalence, we will present the current knowledge on them and evaluate their impacts on Arctic marine mammal health.

3.3 Ocean acidification and the increasing transparency of the ocean to low frequency sound

Peter G. Brewer
Monterey Bay Aquarium Research Institute

pH dependent species involving dissolved borate and carbonate ions affect the absorption of sound in seawater so that as the ocean becomes more acidic it becomes more transparent to low frequency (~10 kHz and below) sound. The effect is quite large; a decline in pH of only 0.3 causes a 40% decrease in the intrinsic sound absorption coefficient (α, dB/km). The fossil fuel CO_2 invasion of the ocean is now lowering pH, and reasonable projections based upon conservative IPCC scenarios show that an anthropogenic change in surface ocean pH of -0.3 will likely occur by mid-century. Since acoustic properties are measured on a logarithmic scale then, neglecting other losses, sound at frequencies important for marine mammals and for naval and industrial interests will travel some 70% further than today. The military and environmental consequences of these changes have yet to be fully evaluated.

The physical basis for this effect is well known: if a sound wave encounters a molecule such as borate ion that can be "squeezed" into a lower volume state a resonance can occur so that sound energy is lost and the molecule then returns to its normal state. Ocean acousticians recognized this pH-sound linkage in the early 1970s but connection to global change and environmental science is in its infancy. Changes in pH in the deep sound channel will be large due to the combination of the fossil fuel CO_2 invasion, and additional change from decreasing O_2/rising respiratory CO_2 from physical climate change, and the acoustic consequences may be felt over thousands of miles.

It is important to recognize that the intrinsic chemical effect described here is a very small component of overall sound loss in the ocean, and that losses from physical scattering and absorption at the ocean surface and sea floor far exceed these terms. The pH effect is significant only at long range, and sound intensity drops off very quickly with distance.

For approximate scale in the 57 Hz antipodal sound transmission of the Heard Island experiment the volume attenuation over 18-Mm (megameters) is 5 dB for the Atlantic and 3 db for the Pacific with its lower pH. Nonetheless it is these terms that are changing due to mankind's activities while other terms remain constant. The effect is significant at low frequencies and the ubiquitous anthropogenic 60Hz and 50Hz signals clearly fall into this category.

This effect may be both troubling and useful, and wisdom will be called for in addressing these issues. Marine animals at mid-water depths now face a basic challenge to life from declining O_2 and rising CO_2 levels, much as would humans in a submarine or space craft. Models predict a very large expansion of ocean dead zones at depths which correlate well with the sound channel. Thus the ocean sound channel will increasingly become a depth zone depleted in marine life with its associated bio-acoustic properties, and increasingly chemically transparent to sound. There are few ways to efficiently document such changes taking place over large length scales and alert a skeptical world. Long range acoustic probing of ocean sound absorption offers one uniquely integrative approach and recent work shows that this is very possible.

4. Noise in cumulative impact assessment: Political frameworks and legal standards and tools

4.1 Noise in cumulative impact assessments for NMFS ESA species/populations: regulatory mandates and methods used in ESA Biological Opinions, with ideas for improvements

Craig Johnson
U.S. National Marine Fisheries Service, Office of Protected Resources
1315 East-West Highway, SSMC3, Silver Spring, Maryland U.S.A. 20910

The U.S. Endangered Species Act of 1973 (as amended) is one of the two primary authorities available to the U.S. government for protecting marine mammals from the adverse effects of human activities. Specifically, section 7(a)(2) of the Endangered Species Act of 1973 (ESA) requires every agency of the U.S. government, with very few exceptions, to insure that any action they authorize, fund or otherwise carry out is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat that has been designated for those species. To comply with this section of the ESA, Federal agencies must "consult" with the National Marine Fisheries Service and the Fish and Wildlife Service (the Services) on actions that may affect threatened or endangered species marine mammals or critical habitat that has been designated for those species.

As a result of this legal requirement, NMFS personnel consult with the U.S. Navy on its training activities; with the Minerals Management Service on oil and gas leasing and seismic exploration on the Outer Continental Shelf of the U.S.; with the National Science Foundation on seismic surveys they fund; with the U.S. Department of Transportation on construction projects that involve pile-driving; among many other categories and kinds of activities. Although the assessment framework NMFS uses to conduct these consultations does not separately consider "cumulative impacts" of these activities (as that term is usually construed for impact assessments), NMFS personnel are required to consider accumulations of effects, interactions, synergisms, and antagonistic effects in their assessments.

NMFS begins its assessments by identifying the physical, chemical, and biotic stressors that would be associated with an action. NMFS personnel then estimate the number of exposure events that are likely to involve endangered or threatened species and designated critical habitat and the circumstances of that exposure. NMFS personnel then assess the probable responses of endangered or threatened individuals to a single exposure event or a series of exposure events, given their exposure to the same or other stressors prior to or contemporaneous with a particular exposure event. NMFS then assessing the probable consequences of those responses on the expected lifetime reproductive success (the current and expected future reproductive success) of the individuals that are expected to be exposed to one or more stressor. If NMFS personnel conclude that one or more individuals are likely to experience reductions in reproductive success, they then assess the probable consequences of those reductions on the viability of the population(s) those individuals represent and conclude by assessing the consequences of any reductions in the viability of one or more populations on the "species" those populations comprise (the ESA defines "species" to include taxonomic species, sub-species, and distinct population segments of vertebrate species). See the attached background document for more detail on this assessment framework and its treatment of cumulative impacts.

NMFS personnel face several obstacles when they try to use this framework to assess the cumulative impacts of anthropogenic noise and other stressors on endangered or threatened marine mammals. The most important obstacle results from the limited number of studies of whether free-ranging animals respond differently to exposure events involving a single stressor versus exposure events

involving multiple stressors and, if so, the differences in those responses. Although the concept of canonical cost proposed by McNamara and Houston (1986), which are reductions in an animal's expected future reproductive success that would occur when an animal engages in suboptimal behavioral acts, provides a currency for assessing cumulative impacts of anthropogenic noise and other stressors on endangered or threatened marine mammals, attempts to convert this concept into a method that can be used to estimate future effects remain elusive.

4.2 Noise in Cumulative impact assessments for NMFS MMPA species/populations: regulatory mandates and methods used in addressing threats to marine mammals, with ideas for improvements

Craig Johnson & Jolie Harrison
U.S. National Marine Fisheries Service, Office of Protected Resources
1315 East-West Highway, SSMC3, Silver Spring, Maryland U.S.A. 20910

The U.S. Marine Mammal Protection Act of 1972 (as amended; MMPA) is one of the two primary authorities available to the U.S. government for protecting marine mammals from the adverse effects of human activities. Specifically, the MMPA prohibits the "take" of marine mammals or those activities that "harass, hunt, capture, or kill or attempt to harass, hunt, capture or kill a marine mammal." However, in several specific circumstances, NMFS can authorize the "take" of marine mammals in one of two ways: by issuing a permit for scientific research and enhancement or by issuing an authorization if the "take" is incidental to activities that would be legal in other respects.

To issue an authorization for incidental "take" of marine mammals, NMFS must make certain that (1) the total "take" will have a negligible impact on the species or stock of marine mammal and (2) will not have an unmitigable adverse impact on their availability for subsistence uses. Authorization and permits NMFS issues identify permissible methods of "take" and means of effecting the least adverse impact practicable on marine mammals and their habitat and specifies monitoring and reporting measures that recipients of these authorization or permits must satisfy.

The framework NMFS uses to assess the effects of MMPA authorizations or permits do not specifically consider the cumulative impacts of activities covered in authorizations or permits. However, NMFS must satisfy the requirements of the U.S. National Environmental Policy Act before it can issue MMPA authorizations or permits, which require explicitly require NMFS to consider the cumulative impacts of any "take" it authorizes. Those cumulative impact analyses are constrained by the limited scientific information available on the effects of interactions, synergisms, and antagonisms among the various physical, chemical, and biotic stressors and stress regimes found in the environment of free-ranging marine mammals.

4.3 Assessing cumulative impact and risk – approaches at the U.S. Environmental Protection Agency[1]

Wayne R. Munns, Jr.
U.S. Environmental Protection Agency, Office of Research and Development

The U.S. Environmental Protection Agency (EPA) has a mission and regulatory mandate to protect human health and the environment. EPA's primary role is to implement environmental laws by developing and enforcing national regulation. Cogent to the goals of this workshop, key environmental laws that EPA administers include the Clean Water Act, the Clean Air Act, and the

[1] This abstract has not been subjected to Agency-level review, and therefore do not necessary reflect the views of the U.S. EPA. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Marine Protection, Research and Sanctuaries Act.[2,3] EPA also has a unique responsibility in the National Environmental Policy Act (NEPA) process, in that under the Clean Air Act, it is required to review and publicly comment on the environmental impacts of major federal actions. EPA's regulatory mission is supported by the research conducted by its Office of Research and Development.

In the late 1980s and early 1990s, EPA regulatory programs began adopting risk assessment as a primary decision informing tool for evaluating the potential impacts of anthropogenic stressors on humans and the environment. Ecological risk assessment is a process for evaluating the likelihood that adverse ecological effects will occur or are occurring as a result of exposure to one or more stressors (U.S. EPA 1992, 1998). It is intended to be a general, organizing process for science-based evaluations of the environmental consequences of human activity. Its concepts and approaches can be applied to problems involving any environmental stressor and the attributes of any species, community, or ecological system or process (the "assessment endpoint" in risk assessment parlance). As practiced historically by EPA (see Suter et al. 2003 for a history of ecological risk assessment), however, ecological risk assessment has been used for regulatory purposes primarily to inform decisions pertaining to the management of chemicals, and usually for single chemicals in isolation or classes of chemicals that act similarly. Further, the majority of past ecological risk assessments have focused on survival, reproduction or individual growth of organisms as their primary measures of effect. Such practices served EPA well in informing the actions that led to control of overt problems of chemical pollution.

Environmental policy and management goals in EPA regulatory programs are evolving. Ecological emphasis is shifting toward protection of populations, habitats, and whole ecosystems in the context of multiple stressors and their cumulative impacts. Parallel evolution is occurring with respect to human health risks. With these changes comes the need for more sophisticated risk assessment planning and methods, ones that can account for environmental complexity and realistic context more effectively than can single-stressor, single-endpoint approaches. Assessments that consider the cumulative risks of multiple stressors provide the arrays of information needed to support the objectives of regulatory, resource management and conservation more comprehensively than do traditional single-stressor impact and risk assessments.

Many specific definitions of *cumulative impact or risk assessment* exist, but all reflect the notion of explicitly considering the aggregate impacts of multiple important agents or stressors on the endpoint or receptor of concern through time. In 2003, EPA released its *Framework for Cumulative Risk Assessment* (U.S. EPA 2003) to articulate an analytic-deliberative process and considerations for performing cumulative risk assessments (CRA) within the Agency. As with EPA's *Framework for Ecological Risk Assessment* (U.S. EPA 1992) before it, this process is intended to be applicable to broad array of environmental problems, and informative to a variety of environmental decisions, including those associated with NEPA. The basic steps of CRA (mirroring those of ecological risk assessment) are: 1) Planning, Scoping and Problem Formulation, within which the risk problem is defined and the assessment is planned; 2) Analysis, primarily an analytic process evaluating the risk problem at hand; and 3) Interpretation and Risk Characterization, focused on integration and interpretation of the results of the Analysis phase. Although CRA as framed by the *Framework* is oriented primarily toward human risk, its approach and considerations can serve as models for

[2] Although EPA has responsibilities under the Endangered Species Act, management of that Act is primarily the responsibility of the U.S. Fish and Wildlife Service.

[3] EPA, under the Noise Control Act of 1972, had promulgated regulations that set maximum noise limits on a number of household, industrial and vehicular sources to protect against adverse effects on humans. However, primary responsibility for regulating noise was shifted to state and local governments in the early 1980s. Although the Noise Control Act and the Quiet Communities Act of 1978 were not rescinded by Congress and remain in effect today, they essentially are unfunded.

assessing cumulative risk to nonhuman receptors and populations, including marine mammals. EPA has begun a process of developing more explicit guidance for performing cumulative risk assessments, which is intended to be vetted and released in the near future.

Importantly, the CRA *Framework* identifies a number of research and development needs that address gaps in the knowledge and methodology required to perform CRA effectively. Included are methods for understanding the timing of exposure to stressors and its relationship to effects, methods for understanding how multiple stressors and their mechanisms of effect interact to result in risk, and methods for combining different types of risk. Such deficiencies in the science supporting CRA surely will affect our ability to assess the cumulative risk of noise and other stressors to marine mammal populations. However, because protection of populations necessarily requires appreciation of the contributions of multiple stressors to risk, increasing emphasis by EPA's Office of Research and Development and other organizations on development of tools to assess population-level risk to wildlife and aquatic life (e.g., U.S. EPA 2004, Munns 2004; also see Barnthouse et al. 2007) should continue to address these deficiencies.

References

Barnthouse LW, Munns WR Jr., Sorensen MT (editors). 2007. Population-level ecological risk assessment. Taylor & Francis, Boca Raton, FL, USA.

Munns, WR Jr. 2006. Assessing risks to wildlife populations from multiple stressors: Overview of problem and research needs. Ecology and Society 11. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art23/

Suter GW II, Norton SB, Barnthouse LW. 2003. The evolution of frameworks for ecological risk assessment from the Red Book ancestor. Human and Ecological Risk Assessment 9:1349-1360.

U.S. EPA. 1992. Framework for ecological risk assessment. EPA/630/R-92/001, Risk Assessment Forum, Washington, DC, USA.

U.S. EPA. 1998. Guidelines for ecological risk assessment. EPA/630/R-95/002F, Risk Assessment Forum, Washington, DC, USA.

U.S. EPA. 2003. Framework for cumulative risk assessment. EPA/630/P-02/001F, Risk Assessment Forum, Washington, DC, USA.

U.S. EPA 2004. Wildlife research strategy. EPA 600/R-04/050, Office of Research and Development, Research Triangle Park, NC, USA.

4.4 Assessing and managing noise in National Parks: lessons for metric and threshold design

Kurt Fristrup

The U. S. National Park System derives its resource management authority from legislation with forceful conservation priorities. The purpose of NPS is "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations (Organic Act of 1916, P. L. 64-235)." This conservation mandate was reinforced by subsequent legislation (General Authorities Act of 1976, P. L. 94-458; The Redwoods Act of 1978, P. L 95-250). NPS management is founded on the principle that conservation will predominate when there is a conflict between resource protection and visitor use (NPS Management Policies, "MP2006").

The Grand Canyon National Park Enlargement Act of 1975 (P. L. 93-620) explicitly recognized "natural quiet as a value or resource in its own right to be protected from significant adverse effect." In addition, the Wilderness Act of 1964 (P. L. 88-577) calls for the enduring preservation of areas with "a community of life untrammeled by man" and "outstanding opportunities for solitude." Accordingly, MP2006 states that unreasonable interference with the "the atmosphere of peace and

tranquility, or the natural soundscape maintained in wilderness and natural, historic, or commemorative locations within the park" constitutes an unacceptable impact. The acoustical environment is protected as a physical resource, like water and air quality. It is also protected due to its value for ecosystem function and visitor experience. "The natural ambient sound level—that is, the environment of sound that exists in the absence of human-caused noise—is the baseline condition, and the standard against which current conditions in a soundscape will be measured and evaluated (MP2006, 8.2.3)."

NPS uses three metrics that reference natural ambient levels: audibility to attentive human listeners, loss of alerting distance, and loss of listening area. The latter two metrics distinguish between conditions in which hearing serves to warn animals of hazards or to cue them to opportunities (e. g. the footfalls of potential predators or prey, respectively). Metrics that document changes in the physical environment, without reference to animal hearing systems, are in development.

NPS marine resources include more than 12,000 km2 of ocean and Great Lakes waters and 8,000 km of shoreline. Glacier Bay NP has monitored noise from cruise ship vessels for several years, and is in the process of developing underwater noise management standards. However, national protocols for underwater acoustical monitoring and noise management have not been established.

NPS efforts to preserve outstanding acoustical conditions have been persistently opposed by other U. S. agencies that have decades of practice managing noise in relation to hearing loss, interference with conversational speech, interruption of sleep, and annoyance. These acute impacts should be rare in national park units, but they are thresholds that must be routinely exceeded before other agencies consider management action. Concerns about precedents, defense of past practices, preservation of established routines: all of these present substantial obstacles to acknowledging affirmative obligations to protect acoustical resources.

5. Quantification of cumulative exposure

5.1 Spatio-temporal aspects of threats in the Arctic relative to marine mammal habitat and distribution

Robert Suydam
North Slope Borough, Department of Wildlife Management
Barrow, Alaska

The Arctic is changing rapidly. The most visible change in the marine environment is the dramatic reduction in the extent of sea ice during the summer. Other environmental changes are also occurring, such as decreased amount of multi-year ice, changes in phenology, and increased coastal erosion. The biological environment is also changing. For example, marine mammals rarely seen in the Arctic are occurring there more regularly. There are likely many other changes of which we are not aware. The reduction in sea ice coverage, thinner sea ice, increased cost of oil, and greater human interest in the Arctic have resulted in plans for increased human activity. That activity includes: oil and gas exploration and development, mining, commercial shipping, science (including mapping of continental shelves), tourism, fishing, and military activities.

My knowledge and experience are mostly focused on the Beaufort and Chukchi seas, adjacent to Alaska, but I also provide a less thorough overview of human activities in other portions of the Arctic.

Russia is looking to the Arctic for its "socio-economic stability and security". There are several main components to their interest in the Arctic, to develop and transport hydrocarbon resources and

commercial shipping through the Northern Sea Route. Mining for metals and coal is also underway. It is likely that Russia will also rebuild their military presence and capability in the Arctic. Norway is developing natural gas fields in the Barents Sea and continues commercial fishing. Greenland is involved in mining, especially for rare metals, exploration for hydrocarbons, and commercial fishing. In Canada, there is increased interest in mining and exploration and development for oil and gas, especially in eastern Beaufort Sea. Commercial shipping through the Northwest Passage is also a possibility. Science and tourism are also increasing. In the U.S. Arctic, Alaska is experiencing increased oil and gas exploration and development, mining, science, and tourism. Shipping and commercial fishing are also activities for which planning is underway.

The timing of these human activities varies. Seismic exploration in offshore areas occurs primarily during the open water months of summer, while exploratory drilling and development can occur throughout the year. Transport of materials from mining operations, science, tourism, and commercial fishing occurs primarily during summer.

The diversity of marine mammals in the Arctic is relatively low. Key species of cetaceans include bowhead, gray, beluga whales and narwhals. Key species of pinnipeds include: bearded, ringed, hooded, ribbon, and harp seals. Some of these species occur in the Arctic primarily in the summer months while others are present year round. There are potential direct impacts to marine mammals from greater levels of anthropogenic sounds, oil spills, ship strikes, and commercial fishing. There are also potential impacts to other marine organisms, habitats, and to the people that live in the Arctic. Understanding the direct impacts from one industrial operation or one activity has many challenges. The Arctic is a difficult place to work. Additionally, there is limited baseline information in many cases. Understanding direct and indirect cumulative impacts is exceedingly difficult yet becoming more important as the environment changes and as human activities increase. Separating impacts from environmental change versus anthropogenic activities will be especially difficult. Additional data are needed on how marine mammals use arctic environments, their population sizes for many species, and habitat models at various scales. Models are needed to predict impacts from both a changing environment and increasing human activities.

5.2 Worldwide threats to marine mammals, ranked in significance and considered in relation to distribution, exposure, and overlap with noise

Randall R. Reeves

Perceptions of threats to marine mammals have changed markedly since the late 1960s and early 1970s, when direct and deliberate off-take[1] (by whaling, sealing, etc.) was by far the principal concern. As the commercial exploitation of seals and whales was scaled down in response to international protest campaigns and policy changes, the emphasis shifted during the 1980s toward incidental removals in fisheries ("bycatch") (Hofman, 1995), which is still widely regarded as the greatest immediate threat to many species and populations (Read, 2008). An extreme imbalance has existed, and continues to exist, between the extent to which threats (individual, much less cumulative) are investigated, understood, and addressed in North America-Europe-Australia-New Zealand vs. in the rest of the world. Recent extinction of the baiji is clear evidence, although the ongoing decline of monk seals in southern Europe and Hawaii should be borne in mind.

In attempting to rank "significance" of various threats,[2] the following criteria are proposed as potentially relevant: (1) degree of certainty regarding cause and effect, (2) immediacy, (3) severity (e.g., in terms of lethal vs. sublethal, acute vs. chronic, and the conservation status of affected taxa

[1] Here meant to include most removals from the wild.
[2] In the present context, a threat is to the persistence of the species or population, not necessarily to the survival or welfare of the individual marine mammal.

[critically endangered, common and widespread, etc.]), (4) reach of the threat (i.e., how widespread or geographically extensive it is), (5) spatial range of species or populations affected, and (6) feasibility of mitigation[3]. Threats to marine mammal species and populations at the global level include, in addition to off-take: toxic contamination (which may affect the animals themselves or their food, or both; this threat includes biotoxins, petroleum products, and a variety of manmade toxins); disease; effects of small population size; death or serious injury from vessel strikes; reduction of or damage to the food base (e.g., due to fishing or other perturbation); and disturbance caused by noise [e.g., seismic profiling, shipping, military sonar], chasing, or spatial displacement [e.g., by aquaculture facilities, windfarms, port development, intensive harbor usage]. Unlike terrestrial organisms and some other groups of marine animals, the marine mammals are not generally threatened by invasive species[4] or habitat fragmentation, degradation, and loss, although habitat alteration is a major threat to manatees, seals, and dolphins living in running freshwater systems, estuaries, and very near-shore marine waters (e.g., Reeves et al., 2000; Smith and Jefferson, 2002).

Some threats, such as ocean acidification and climate change, are pervasive, insidious, complex, and difficult to characterize, quantify, or track in relation to individual species or species groups. Their effects are often indirect. For example, climate change will likely "alter the exposure levels of marine mammals to a variety of toxicants through … changes in distribution of harmful algal blooms…, changes in long-range atmospheric and oceanographic transport (including interactions with sea ice), biotransport, changes in feeding ecology, increased and altered runoff, and increased human involvement in the Arctic" (Burek et al. 2008, p. S130). The aggregate negative effects of climate change could ultimately dwarf those of all other threats, combined, on some species (e.g., polar bear, walrus, ice seals, arid-region river dolphins).

The recent attempt by Schipper et al. (2008) to analyze and map global mammalian diversity, threats, and knowledge (based on IUCN Red List assessments) provides a possible starting point for integrating multiple categories of information to identify hotspots of risk. Their study found that nearly 80% of marine mammal species are threatened by "accidental mortality" (including bycatch and ship strikes), 60% by "pollution" (defined to include noise as well as chemical toxicants), and about half by "harvesting." Particularly striking is that nearly 45% of marine mammals are classified as either Near Threatened or Data Deficient, meaning the proportion of threatened species (Critically Endangered, Endangered, or Vulnerable) could be considerably higher than the current estimate of about 23%. A broadly similar but much more focused and detailed study of the marine mammals alone might be informative. It would be desirable if such a study were to incorporate, among other things, finer-scaled GIS mapping of threats (e.g., with exposure to noise and to chemical contaminants considered separately) and species data (e.g., with at least some species broken down into subspecies or populations with differing status and distribution).

References

Burek, K.A., Gulland, F.M.D., and O'Hara, T.M. 2008. Effects of climate on Arctic marine mammal health. *Ecological Applications* 18(2) Supplement:S126-S134.

Hofman, R.J. 1995. The changing focus of marine mammal conservation. *Trends in Ecology & Evolution* 10:462-465.

Read, A.J. 2008. The looming crisis: interactions between marine mammals and fisheries. *Journal of Mammalogy* 89:541-548.

[3] Inclusion of this criterion needs careful consideration in the context of cumulative impacts. In many instances, infeasibility of mitigation would likely *increase* a threat's significance.

[4] Here meaning specifically alien species introduced to an area through human agency, and not species moving on their own into "new" areas as environmental conditions change.

Reeves, R.R., Smith, B.D., and Kasuya, T. (eds.). 2000. Biology and conservation of freshwater cetaceans in Asia. *IUCN SSC Occasional Paper* 23: 152 pp.
Schipper, J., Chanson, J.S., et al. 2008. The status of the world's land and marine mammals: diversity, threat, and knowledge. *Science* 322:225-230.
Smith, B.D., and Jefferson, T.J. 2002. Status and conservation of facultative freshwater cetaceans in Asia. *Raffles Bulletin of Zoology*, Suppl. 10:173-187.

5.3 Determining and mapping cumulative exposures in the marine environment

Carrie V. Kappel[1], Benjamin S. Halpern[1], Kimberly A. Selkoe[1,2]
[1] National Center for Ecological Analysis and Synthesis, University of California Santa Barbara; [2] Hawaii Institute of Marine Biology

The management and conservation of the world's oceans require spatial data on the distribution and intensity of human activities and their cumulative impacts on marine ecosystems and species. We developed an ecosystem-specific and scale-independent spatial model to synthesize 17 global datasets of anthropogenic drivers of ecosystem change for 20 marine ecosystems (Halpern *et al.* 2008). Our analysis indicates that no area is unaffected by human influence and that a large fraction (41%) is strongly affected by multiple drivers. However, areas of relatively minimal human impact remain, particularly near the poles, but also in other locations scattered across the globe. The analytical process and resulting maps provide flexible tools for regional and global efforts to allocate conservation resources, implement ecosystem-based management, and inform marine spatial planning. We have also applied these same methods to the Northwest Hawaiian Islands (14 human activities and 10 ecozones; Selkoe *et al.* 2009) and to the California Current, using more comprehensive and higher-quality data for 25 human activities and 19 marine ecosystems (Halpern *et al.* 2009). The latter analysis indicates where protection and threat mitigation are most needed in the California Current and reveals that coastal ecosystems near high human population density and the continental shelves off Oregon and Washington are the most heavily impacted, climate change is the top threat, and impacts from multiple threats are ubiquitous. Remarkably, these results were highly spatially correlated with global results for this region ($R^2 = 0.92$), suggesting that the global model provides guidance to areas without local data or resources to conduct similar regional-scale analyses.

While this framework has yet to be applied to cumulative effects on species or populations, it is designed to be flexible and transferrable. We discuss here the potential to apply it to assessing marine cetaceans' cumulative exposures to anthropogenic impacts. There are several important differences when applying the framework to species rather than ecosystems. More empirical data and models may be available with which to judge relative vulnerability of populations to individual impacts, reducing our reliance on expert judgment to calibrate vulnerability weights used in the cumulative impact model (see Halpern *et al.* 2007). Second, our spatial snapshot approach may be insufficient; we need new methods for accumulating impacts in time as well as space. Finally, spatiotemporal dynamics of migratory populations will be critical to determining exposures. Transferrable methods include using expert judgment to fill data gaps, using ecological vulnerability measures to standardize scoring of vulnerability, and applying our cumulative impact GIS model. Mapping of many important stressors (and habitats, which may be helpful in mapping cetacean distributions) has already been completed at the global scale and in more detail for particular regions. A starting point for applying this framework to cetacean cumulative impacts is to develop seasonal snapshot maps of cumulative impacts for populations in their breeding and foraging areas and along key migratory corridors. Doing so would allow us to begin to visualize the seascape of threats to cetaceans and to think about them in the context of broader ecosystem impacts.

References

Halpern, B.S., C.V. Kappel, K.A. Selkoe, F. Micheli, C. Ebert, C. Kontgis, C.M. Crain, R.G. Martone, C. Shearer, S. Teck. 2009. Mapping cumulative human impacts to California Current marine ecosystems. Conservation Letters 2: 138-148.

Halpern, B.S., K.A. Selkoe, F. Micheli, and C.V. Kappel. 2007. Evaluating and ranking the vulnerability of marine ecosystems to anthropogenic threats. Conservation Biology 21: 1301-1315.

Halpern, B.S., S. Walbridge, K.A. Selkoe, C.V. Kappel, F. Micheli, C. D'Agrosa, J. Bruno, K.S. Casey, C. Ebert, H.E. Fox, R. Fujita, D. Heinemann, H.S. Lenihan, E.M.P. Madin, M. Perry, E.R. Selig, M. Spalding, R. Steneck, R. Watson. 2008. A global map of human impact on marine ecosystems. Science 319: 948-952.

Selkoe, K.A., B.S. Halpern, C.M. Ebert, E.C. Franklin, E.R. Selig, K.S. Casey, J. Bruno, R.J. Toonen. 2009. A map of human impacts to a "pristine" coral reef ecosystem, the Papahānaumokuākea Marine National Monument. Coral Reefs. Published online 25 March 2009. DOI 10.1007/s00338-009-0490-z

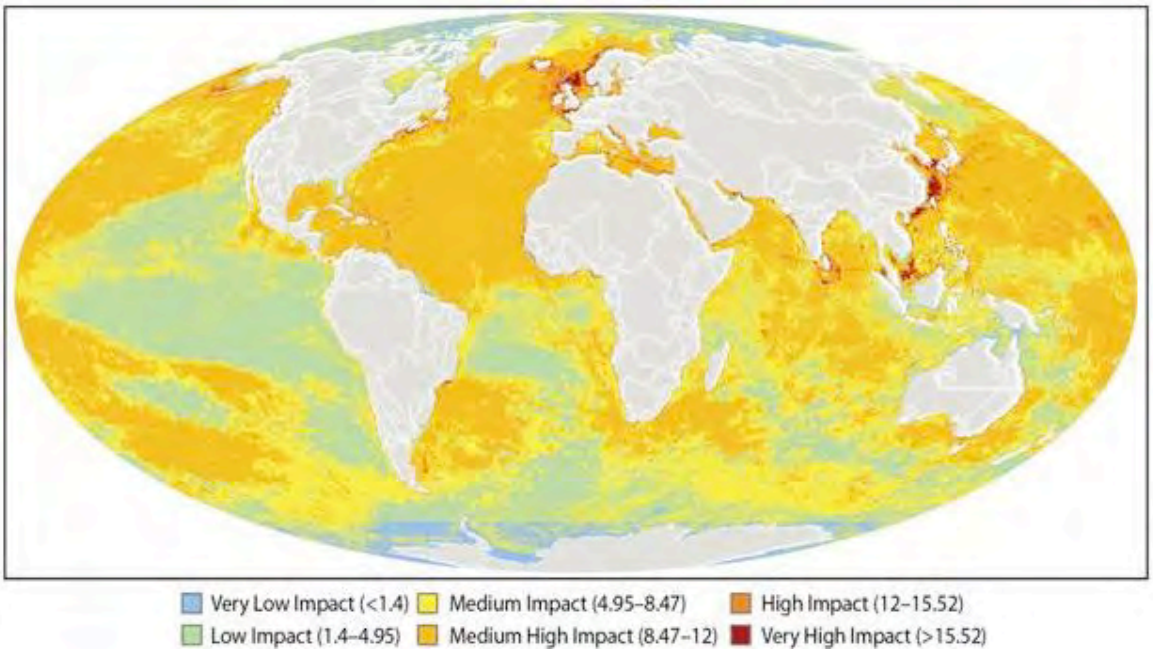


Figure 1. Global map of cumulative effects on marine ecosystems from Halpern *et al.* 2008. White lines on the continents represent watershed boundaries from which land-based effects were derived.

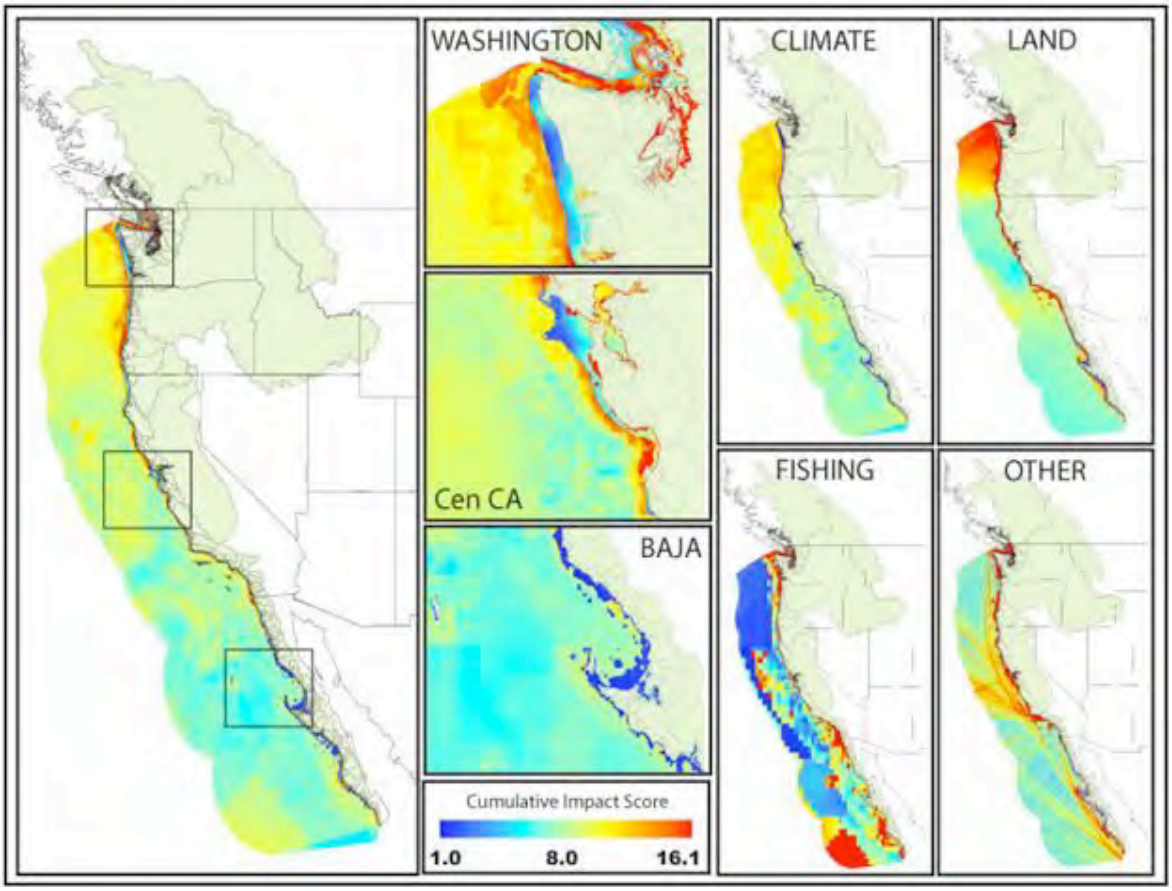


Figure 2. Cumulative impact map of 25 different human activities on 19 different marine ecosystems within the California Current with close-up views of three regions (Washington State, central California, and central Baja California), and impact partitioned into four sets of human activities of particular interest: climate change (n =3 layers), land-based sources of stress (n = 9 layers), all types of fishing (n = 6 layers), and other ocean-based commercial activities (n = 7 layers). Puget Sound is the reticulated bay in Washington, San Francisco Bay is the large bay in Central California, and Tijuana is at the Mexican border with California. From Halpern *et al.* 2009.

5.4 Modeling cumulative sound exposure over large areas, multiple sources and long durations

Christine Erbe
JASCO Applied Sciences, Brisbane Technology Park, PO Box 4037, Eight Mile Plains, Qld 4113, Australia, Christine.Erbe@jasco.com

A software tool is presented for mapping cumulative sound exposure levels from multiple, moving, pulsed or continuous sound sources over large areas and long durations. The tool is illustrated for the example of a marine seismic survey. There were 5,000 shots spread out over 400 km^2 of coral reef. The survey took six weeks. Animals of concern were resident fish who were not expected to leave the reef but who had been shown to ‘simply’ hide amongst the coral for the full duration of a seismic survey elsewhere. The goal was to produce a map of cumulative received sound exposure levels at the reef from the entire survey. The challenge was to account for all the different sound propagation paths from 5,000 source locations to a fine grid of receiver locations.

Solution:
1. Place an evenly-spaced receiver grid over the area.

2. Extract bathymetry profiles for all shot-receiver pairs.
3. Cluster bathymetry profiles with a self-organizing neural net.
4. Model transmission loss along all cluster centroids.
5. Extrapolate transmission loss for all other shot-receiver pairs.
5. Integrate energy at all receivers over all shots (=integration over time and area).

Options:
In the presented example, bathymetry was the single most important factor affecting sound propagation. Bathymetry varied from being very steep on the outsides of the reef to very flat in the reef centre. Large coral outcrops existed all over the reef, sometimes reaching the water surface and stripping energy at high frequencies. Geology (geoacoustic parameters of the seafloor) and sound speed profiles of the water column did not vary substantially over the reef. In other environments, where the geology or water properties are not homogeneous, environmental provinces should be defined and the model run for each province separately.

Applicability:
The tool is useful for moving sources or for very large numbers of sources where an integration in area (over all source locations) is necessary. If only a few stationary sources exist, it will be easier to model sound propagation once for each source and to integrate over time. The tool is useful to assess impact on marine species that are confined to the area modeled (i.e. they don't flee the area), e.g. fish at a coral reef, dugong confined inside a bay etc. The tool produces a sound exposure map, which can be overlain with habitat maps to estimate the percentage of habitat that receives certain threshold levels.

A full article on this model with all references can be found at:

Erbe, C., and A.R. King (2009) "Modeling cumulative sound exposure around marine seismic surveys", *Journal of the Acoustical Society of America* 125(4): 2443-2451.

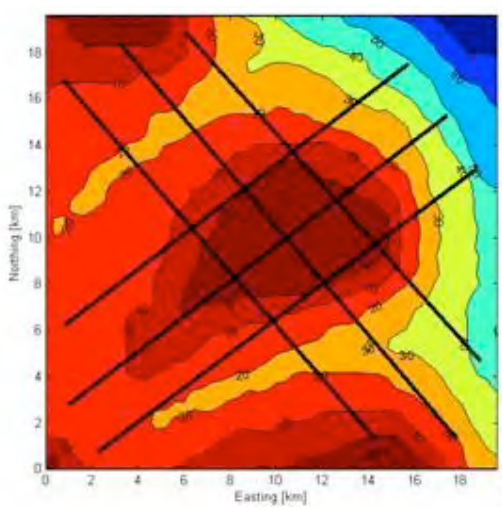


Fig.1: Coral reef of 20km x 20km size.

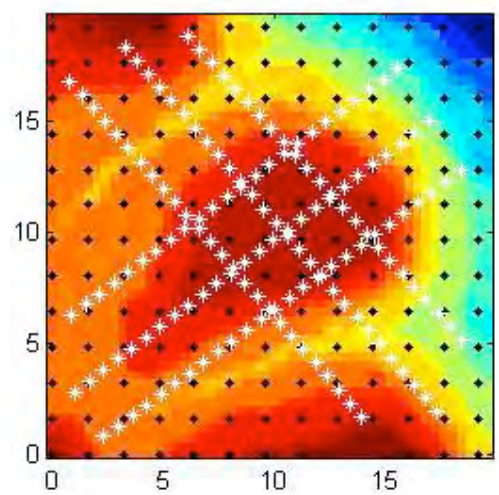


Fig.2: Every 32nd shot (white) + a coarse receiver grid (black).

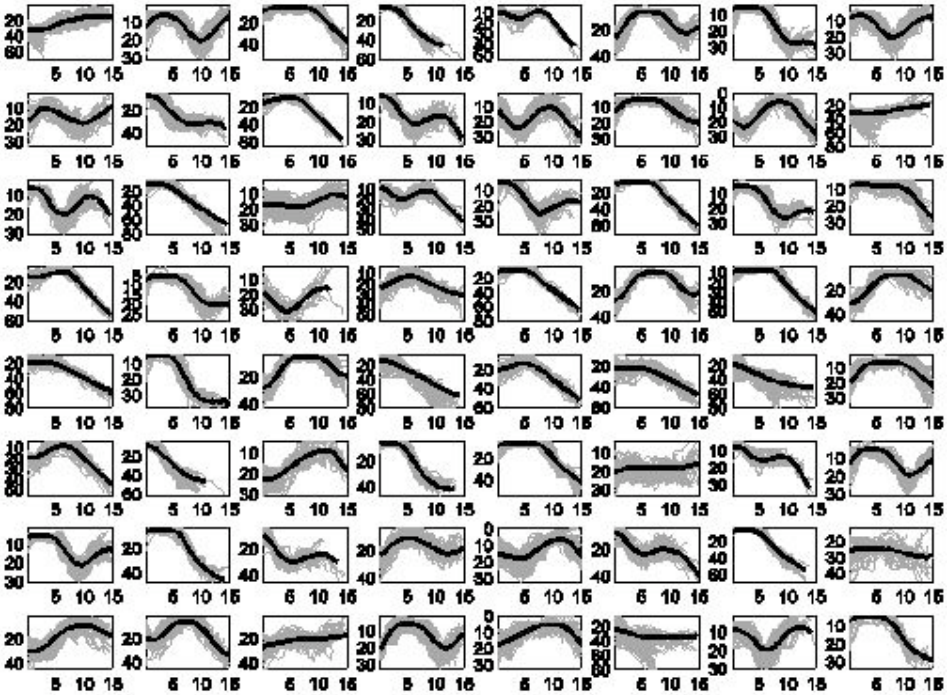


Fig.3: 64 clusters of bathymetries (x: range, y: depth [m]) connecting all shots with all receivers. Centroids in black.

Category	Area receiving this level [km^2]	% of total reef area
SEL > 190 dB re 1 µPa^{2}s	5.80	1.54 %
SEL > 195 dB re 1 µPa^{2}s	2.72	0.72 %
SEL > 200 dB re 1 µPa^{2}s	0.48	0.13 %

Table 1: Total ensonified areas of this reef.

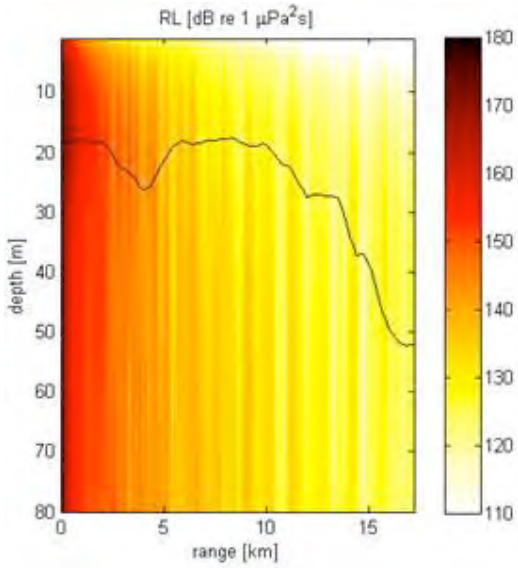


Fig.4: Sound propagation along 1 centroid.

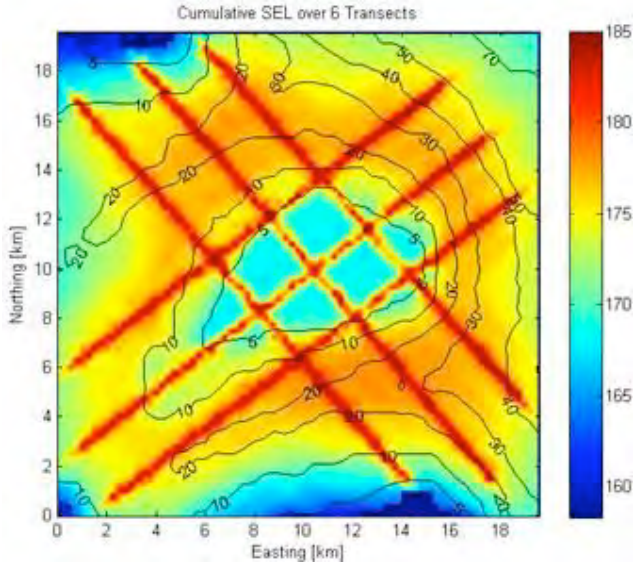


Fig.5: Total SEL from entire survey over whole reef.

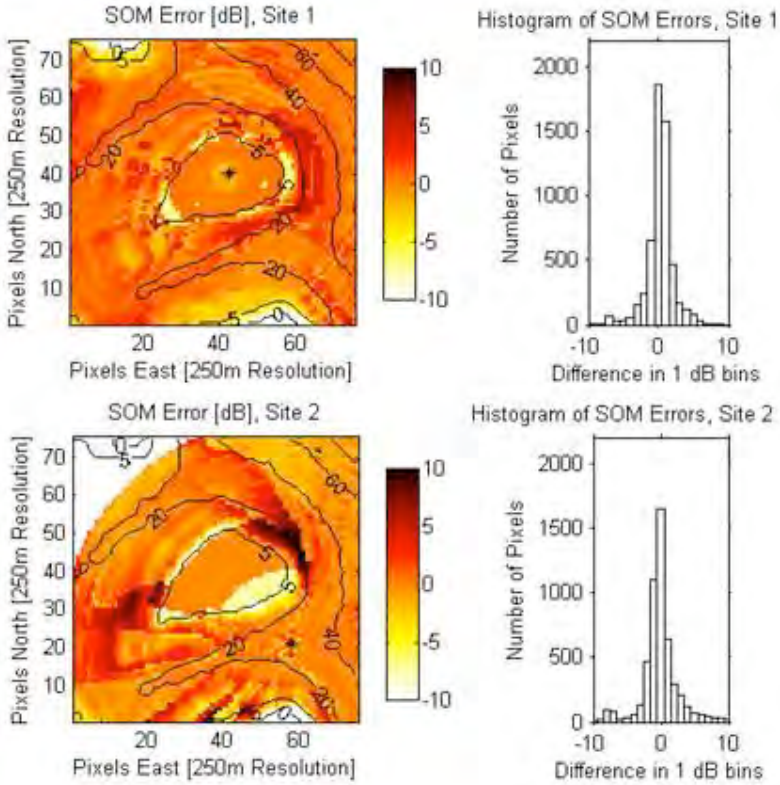


Fig.6: Error of the algorithm compared to modeling each source individually. Error is largest where bathymetry changes rapidly. Mean error: -1 ± 3 dB re 1 µPa^{2}s.

6. Quantification of cumulative impacts

6.1 Assessment of cumulative effects in the Canadian Arctic

Jeffrey E. Green, M.Sc., R.P. Bio.
Senior Principal, Environmental Management
Stantec

Introduction

Assessment of cumulative effects is a required component of the environmental assessment for most large project applications in Northern Canada. This brief note provides an overview of:

- regulatory requirements
- a regional overview of current human activities
- typical approaches used in current assessments
- strengths of current approaches
- challenges in improving cumulative effects assessment

Regulatory Requirements

Environmental reviews and approvals for Projects under federal jurisdictions are set out in the Canadian Environmental Assessment Act (CEA Act). The requirement for assessment of cumulative effects in the environment is set out in Section 16(1) of the CEA Act; specifically:
16. (1) Every screening or comprehensive study of a project and every mediation or assessment by a review panel shall include a consideration of the following factors:

- *the environmental effects of the project, including the environmental effects of malfunctions or accidents that may occur in connection with the project and any cumulative environmental effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out;*
- *the significance of the effects referred to in paragraph (a);*

Additional direction on assessment of cumulative effects under the CEA Act is provided in the Cumulative Effects Assessment Practitioner's Guide (Hegmann et al. 1999).

Within northern Canada, the requirement for environmental assessment is entrenched the land claim agreements for the Inuvialuit Settlement Region (ISR) and Nunavut. In the ISR, environmental assessments must meet the requirements of the CEA Act, as well as the requirements of the Inuvialuit (see below). Within Nunavut, the Nunavut Land Claims Agreement (NLCA) supersedes the CEA Act; environmental assessments must meet the requirements of the Nunavut Impact review Board (see below). The CEA Act would only apply if the physical components of a Project and/or the environmental effects of a Project were to cross the boundary between a provincial or territorial jurisdiction; or extend beyond the NSA into federal jurisdiction, including international issues.

The Inuvialuit Final Agreement (IFA) was signed in 1984 between the Committee for the Original People's Entitlement (COPE) (representing the Inuvialuit of the Inuvialuit Settlement Region) and the Government of Canada. Section 11 of the IFA establishes a formal Environmental Impact Screening and Review Process for proposed projects. Two separate and distinct bodies may be involved in the review of a project proposal:

- the Environmental Impact Screening Committee (EISC)
- the Environmental Impact Review Board (EIRB)

These bodies have assessed a number of offshore projects, mainly in relation to the oil and gas industry. The requirement for cumulative effects assessment is defined in the Operating Guidelines and Procedures for the EISC (EISC 2004); specifically:
"Developers are expected to identify and assess the cumulative effects of the proposed development and other activities in the area. Depending on the development, the assessment of cumulative effects may be qualitative rather than quantitative."

The guidelines are currently being revised. Based on the draft revisions, cumulative effects are defined as "A change to the environment that is caused by a human action in combination with other past, present and reasonably foreseeable actions; and, a cumulative effect on Inuvialuit harvesting as a change to present or future harvesting opportunities caused by a human action in combination with other past, present and reasonably foreseeable actions" (EISC 2009). Additional guidance on assessment of cumulative effects is provided in EISC and EIRB (2002).

The Nunavut Land Claims Agreement (NLCA) was signed in May 1993 between the Tungavik Federation of Nunavut (representing the Inuit of the Nunavut Settlement Area, then part of the Northwest Territories) and the Government of Canada, subject to the Constitution Act of 1982. The Nunavut Impact Review Board (NIRB) is responsible for screening project proposals and, if so determined, review of project proposals within the NSA. Reviews are conducted pursuant to Article 12 of the NLCA, and must take into account both ecosystem and social-economic effects of a project.

The requirement for assessment of cumulative effects is outlined in by NIRB (2006); specifically:
"The assessment of impacts on the biophysical and socio-economic environment that results from the incremental effects of a development when added to other past, present, and Reasonably

Foreseeable Future Developments, regardless of what agency or person undertakes such other developments. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

To date, NIRB has assessed marine aspects for several projects, primarily involving shipping associated with mines, extension of roads or port development.

Regional Overview of Current Human Activities

The Inuvialuit Settlement Area includes all of the Mackenzie River Delta, the Canadian Beaufort Sea and some of the high arctic islands in Canada. Under the IFA, the Inuvialuit have title to lands, as well as rights to financial compensation, rights to harvesting of wildlife and fish, and wildlife compensation.

Human activities in the marine areas of the ISR include nearshore and offshore seismic and exploration drilling, supply shipping for northern communities, limited volumes of other shipping traffic (cruise ships and defence), aircraft overflights, and traditional harvesting. The oil and gas industry has been active in the ISR since the early 1960s, with offshore activity reaching the highest levels during the 1970s-1980s. To date, 86 offshore exploration wells have been completed in the offshore. No production has occurred to date.

The Territory of Nunavut spans most of the high arctic islands in Canada, as well as the land area between Hudson Bay in the west and the Northwest Territories (and the ISR) in the east. The Nunavut Settlement Area, as specified in the NLCA, includes the entire land base within Nunavut, as well as marine areas out to the 12-mile territorial limit or, in the case of the east coast of Baffin Island, the outer landfast ice zone. Under the NLCA, the Tungavik Federation of Nunavut (TFN) have title to approximately 350,000 square kilometres of land, of which 35,250 square kilometres include mineral (sub-surface) rights.

Human activities in the nearshore and offshore are similar to those described for the ISR, but also have included regular annual shipping of ore and products from several mining projects on the arctic islands and Nunavut mainland. Offshore oil and gas primary activity in Nunavut occurred primarily during the 1970s, with most activity occurring in the high arctic islands. Oil was produced from the Benthorn well and shipped to eastern Canada from 1985 through to 1997.

Typical Approaches used in Current Assessments

Based on input from Inuvialuit and Inuit, regulators, and management agencies, assessments for marine mammals typically have focused on Valued Environmental Components (VECs) such as bowhead whale, beluga whale, polar bear and narwhal (Nunavut only). Effects from routine project activities that have been considered include:

- underwater noise resulting in physical harm (this effect is usually screened from detailed assessment due to low probability of occurrence)
- behavioural responses to underwater noise and use of summer habitat in the Canadian Beaufort (e.g., changes in feeding, migration and nursing)
- mortality risk (vessel strikes)
- combined effects of above

Assessments have also considered accidents or malfunctions and cumulative effects.

Assessment of cumulative effects first typically consider each different effect separately, and generally involve the following tasks:

1. Screening of how each individual effect may interact cumulatively with similar effects from other human activities and projects (past, present and foreseeable future)
2. Development of an activity and project inclusion list for the geographic scope of the assessment. Some assessments qualitatively discuss similar effects in other parts of the VEC's range
3. Scoping of assessment in terms of issues of concerns, spatial and temporal boundaries, terms or definitions for characterizing effects (e.g., scope, magnitude, duration, frequency, reversibility), and identification of thresholds for determination of significance
4. Description of mechanism(s) through which the cumulative effect(s) may occur
5. Identification of mitigation by proponent and regional initiatives
6. Assessment of cumulative effect (often based on spatial analyses with consideration of seasonal or inter-annual aspects), and characterization of these effects (as noted above)
7. Determination of significance with reference to:

- Significance of the cumulative effect from all sources
- Contribution of Project to the cumulative effect

Significance is typically related back to the sustainability of the designated population unit (e.g., Bering-Chukchi-Beaufort bowhead population; eastern Beaufort Sea (EBS) beluga population).

Once all of the individual effects are assessed, some assessors have attempted to qualitatively discuss how combined cumulative effects may affect the sustainability of the designated population unit. For example, how might changes in habitat use, mortality and/or contaminants in the food chain interact and cumulatively affect the overall sustainability of the population unit. This may include a discussion of pressures on a VEC in others areas of its annual range, and overall health and status of the population unit for the VEC when it enters and exits the geographic scope of the cumulative effects assessment.

Strengths of the Current Approach

The regulatory system in the ISR has been operational for over two decades, while the current regulatory system in Nunavut has been operational for approximately a decade. While the regulatory requirements and current approaches do focus the assessment of cumulative effects on specific projects and interactions of these projects with other activities and projects, the current approaches do have a number of strengths. These include:

- Involvement of aboriginal people and stakeholders throughout the regulatory and assessment process and project implementation. Both the IFA and NLCA include specific requirements for community engagement in scoping of assessments, planning of field research, and review of assessments.
- Strong focus by Inuvialuit and Inuit on species or species groups that are of high interest to them, including species of concern and harvested species. Marine mammals and individual species are consistently given a high profile.
- Both the IFA and NLCA include direction that traditional knowledge must be given equal weight to western science in environmental assessments and resource management decisions. Traditional knowledge, in practice, is strongly based on a holistic view of the environment. Accordingly, Aboriginal people often raise concerns about the overall effects of a project on the VEC and the environment that supports the VEC.
- Strong involvement of Aboriginal people in the decision making process. Both the EISC and the EIRB in the ISR and the NIRB in Nunavut require equal or majority participation by Aboriginal people. Aboriginal people also have strong representation on wildlife management and resource management organizations.

- All regulatory boards have the ability to seek input from adjacent jurisdictions. For example, the Inuvialuit have considered input from the Inupiat and Gwich'in in Alaska. Both the IFA and the NLCA have provisions for involvement of adjacent territories and provinces.
- The northern regulatory bodies can attach condition to approvals, including:
  - changes to project design or operations
  - additional mitigation and environmental protection planning
  - requirements for additional field studies or follow-up monitoring
- Northern regulatory boards do refer to past environmental effects monitoring (e.g., effects of underwater noise on marine mammals, effects of water-based drilling muds) when formulating their decisions on projects.

Challenges in Improving Cumulative Effects Assessment

Assessment of cumulative effects on marine mammals is a complex challenge that requires consideration of a broad range of potential effects on a population unit throughout its annual range, as well as consideration of multiple stressors within the geographic scope of a specific assessment. Some of the challenges faced by practitioners include:

- Jurisdictional, regulatory and practical considerations often limit the assessment to a specific geographic area (i.e., the ISR, Nunavut).
- Estimating the effects on a VEC from other stressors throughout the annual range of a population unit. For example, when a cumulative effects assessment is limited to a defined geographic area by the factors noted above, how can the status of a mobile species such as bowhead whale or beluga whale be established when they enter and exit arctic Canadian waters?
- Practitioners may have to identify a broad range of existing activities and projects that will or may result in similar effects to the project under consideration. Obtaining information on the spatial and temporal aspects of past and present projects is difficult, particularly with respect to unregulated activities and development. It is also challenging to accurately forecast what activities and projects may occur in the future, and especially difficult to quantify the spatial and temporal nature of effects from these future projects. There is also considerable debate over how far in to the future an assessment should be extended.
- Defining the appropriate population unit. For a specific area or region, are subpopulations, matrilines or other population units most suitable as a basis for the assessment?
- Understanding the effect mechanism(s). Some effects mechanisms are not yet well understood. For example, how do observed or predicted behavioural responses to underwater noise affect the health of individual animals and, in turn, how do these changes affect the long-term sustainability of the population unit under consideration.
- Quantifying individual cumulative effects. What are preferred methods and measurable parameters for assessing specific effects on a VEC and quantifying these effects in terms of scope, magnitude, duration, frequency, etc.?
- Considering cumulative project effects in the context of climate change. Given the rapid changes in ice cover in the Arctic, how are these changes detrimentally or positively affecting marine mammals, and how might these changes interact with other effects of human development and associated activities?
- Qualifying or quantifying the combined cumulative effect on a VEC (i.e., how do we deal with additive and synergistic effects).
- Confirming project effect and cumulative effect predictions. While some information was obtained during past periods of industrial activity, additional effort is needed to monitor responses of marine mammals and other marine biota to specific types of industrial and other human activity to better understand effect mechanisms and better quantify species responses to individual or multiple stressors.

- Developing and verifying thresholds for specific effects or suites of effects. Few, if any, thresholds exist for individual or cumulative effects on marine mammals. For example, what are appropriate acoustic thresholds for marine mammals in arctic regions (e.g., are recommendations by Southall et al. (2008) applicable to species in the Canadian arctic and, if so, how?).
- Confirming the effectiveness of mitigation and management. Industry and government agencies have developed and implemented different approaches to better manage or mitigate project and cumulative effects on marine mammals. How can we best assess if these measures are effective in minimizing an effect or suite of effects to marine mammals?

References

EISC. 2004. Operating Guidelines and Procedures. Prepared by the Environmental Impact Screening Committee. 65 pp.

EISC. 2009. Draft Operating Guidelines and Procedures. Prepared by the Environmental Impact Screening Committee. 65 pp.

EISC and EIRB. 2002. Cumulative Effects assessment in the Inuvialuit Settlement Region. A Guide for Proponents. Prepared for the EISC an EIRB, by KAVIK-AXYS Inc.

Hegmann, G., C. Cocklin, R. Creasey, S. Dupuis, A. Kennedy, L. Kingsley, W. Ross, H. Spaling and D. Stalker. 1999. Cumulative Effects Assessment Practitioners Guide. Prepared for the Canadian Environmental Assessment Agency. 71 pp + Appendices.

NIRB. 2006. Guide 7. Guide to the Preparation of Environmental Impact Statements. Nunavut Impact Review Board. 8 pp.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2008. Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals, In Press.

6.2 *Cumulative impact assessment in Canada: A critique*[5]

Lorne Greig

This paper touches on the legislative framework for cumulative impact assessment (CIA) in Canada, current practices that limit the utility of CIA, and key needs for redeploying CIA in a meaningful way. In much of the legislation and literature, the term cumulative effects assessment (CEA) is used rather than CIA. With regard to the interpretation of "effects" this may be a critical distinction.

Legislative Framework

Environmental assessment (EA) in Canada is mandated provincially, territorially and federally by a variety of legislative instruments. Some provinces explicitly require consideration of cumulative effects (CEs) in their legislation while others do not. Assessment of cumulative effects is required only by British Columbia, Alberta and Quebec, Yukon, Northwest Territories (NWT, Mackenzie Valley Resource Management Act, by the Inuvialuit Settlement Agreement, and the Nunavut Land Claims Agreement. Federally, explicit consideration of cumulative effects is required by the Canadian Environmental Assessment Act (*the Act*). Regarding management of Canada's marine waters, the Oceans Act provides for designation of Marine Protected Areas, and prohibition of some classes of activities within them. It does not otherwise provide specific management powers, but extends other Canadian laws (federal and provincial) into Canada's territorial sea. Management of marine cumulative effects requires extraordinary governmental collaboration and co-operation.

[5] Prepared for Okeanos Foundation Workshop on Assessing the Cumulative Impacts of Underwater Noise with Other Anthropogenic Stressors on Marine Mammals: From Ideas to Action. Monterey California. August 2009.

Central Problems with CEA Practice

What we are concerned about with CIA is the consequence of the totality of pressures that act on a valued ecosystem component (VEC). Duinker and Greig (2006) identify six key problems with CEA practice in Canada:

1) Application of CEA in Project EA,
2) Focus on project approval,
3) Separation of CEs from project specific impacts,
4) Interpretations of cumulative effects,
5) A lack of understanding of ecologic thresholds, and
6) Consideration of future developments.

The application of CEA within project EA is problematic as CEA and EA are rooted in fundamentally different perspectives. CEA must be done from the perspective of the VECs we are concerned about (a VEC-centric view Figure 1), while EA typically takes a project-centric approach (Figure 2).

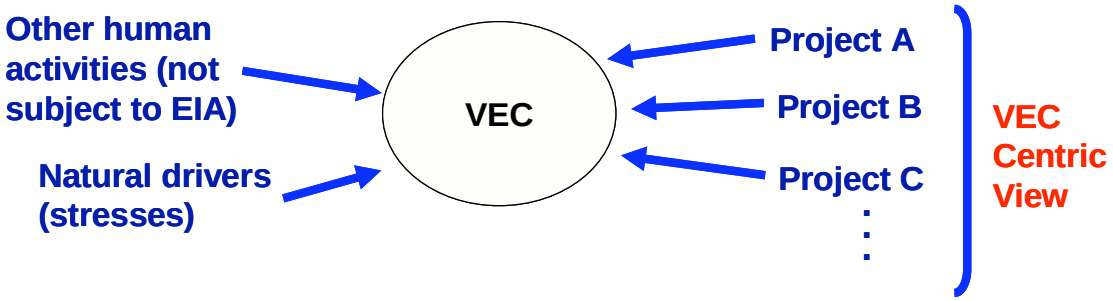


Figure 1: Analytical view required for CEA.

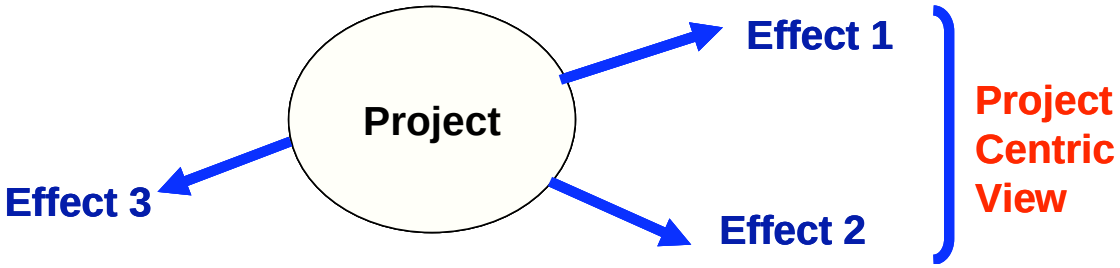


Figure 2: Analytical view typically taken in project EA.

Give this dichotomy, project EA is an inappropriate frame for CEA. In practice, CEAs prepared under the Act tend to be done as a separate add on to the EA, are frequently qualitative and tend to be severely limited by their interpretation of CEs.

The Act defines CEs only implicitly in its requirement that project assessments consider CEs that "are likely to result from the project in combination with other projects or activities that have been or will be carried out". Despite some good guidance, proponents are left to interpret this language. Common interpretations are that CEs occur (only) in some interaction with other projects. Decision trees are often used to establish when CEs occur (Figure 3). With this approach, a project that imposed direct mortality and another that reduced habitat would not be considered jointly to cause CEs, nor would two that both imposed noise pollution on marine mammals but which occurred at different times or in different locations. This is a totally inadequate interpretation of the concept of CEs.

Thus the search for "cumulative effects" becomes a diversion that is not helpful in the search for meaningful conclusions about the consequence of cumulative pressure on resources. Instead CEA in Canada needs to be refocused as an analysis of the ecological sustainability of VECs under the totality of natural drivers and human pressures.

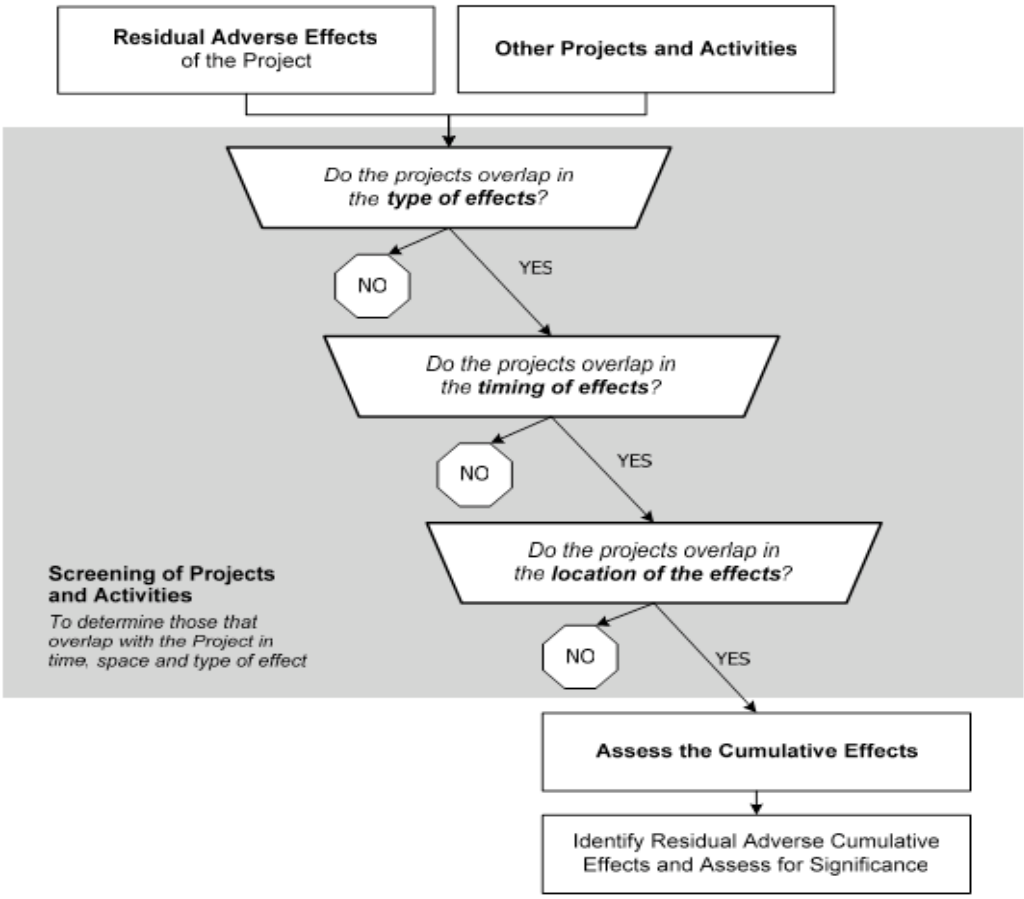


Figure 3: An example of a cumulative effects decision tree (Golder Associates Ltd., 2008).

References

Duinker, Peter N. and Lorne A. Greig. 2006. The Impotence of Cumulative Effects Assessment in Canada: Ailments and Ideas for Redeployment. Environmental Management Vol. 37 No. 2 pp 153 – 161.

Golder Associates Ltd. 2008. Bruce New Nuclear Power Plant Project Environmental Assessment. Environmental Impact Statement Volume 1: Methods, Project Description, and Existing Environment. pp. 832.

6.3 Calculating synergistic and antagonistic impacts: lessons for the marine environment

Kristy Kroeker

Determining the cumulative effects of multiple stressors requires a conceptual model of how individual stressor effects can accumulate. In the simplest scenario, one can use an additive model for which the null hypothesis predicts the combined effect of two stressors is the algebraic summation of the singular effects. Cumulative effects are then categorized as additive, synergistic, or antagonistic based on their relation to the predicted additive response (Folt et al. 1999). The designation of interactive effect types is highlighted in figure 1 (excerpted from Crain et al. 2008).

In the most common case, when both stressors have a negative effect on the response variable (Fig. 1A), the cumulative effect would be designated additive if the response to multiple stressors is the summation of responses to the singular stressor treatments. If the response is significantly less than the predicted additive response (i.e. the cumulative effect is greater than the sum of the singular treatment effects), it is designated synergistic. If the response is greater than predicted additive response (i.e, the cumulative effect is less than the sum of the singular treatment effects), it is designated antagonistic. The interpretation of additive, synergistic, or antagonistic cumulative effects will vary depending on the direction of the responses to singular treatments. In addition to this example of a stressor negatively impacting the response variable (Fig. 1A), the singular stressors may both increase the response variable (Fig. 1C), or one stressor increases the response variable while the other stressor decreases it (Fig. 1B; Crain et al. 2008).

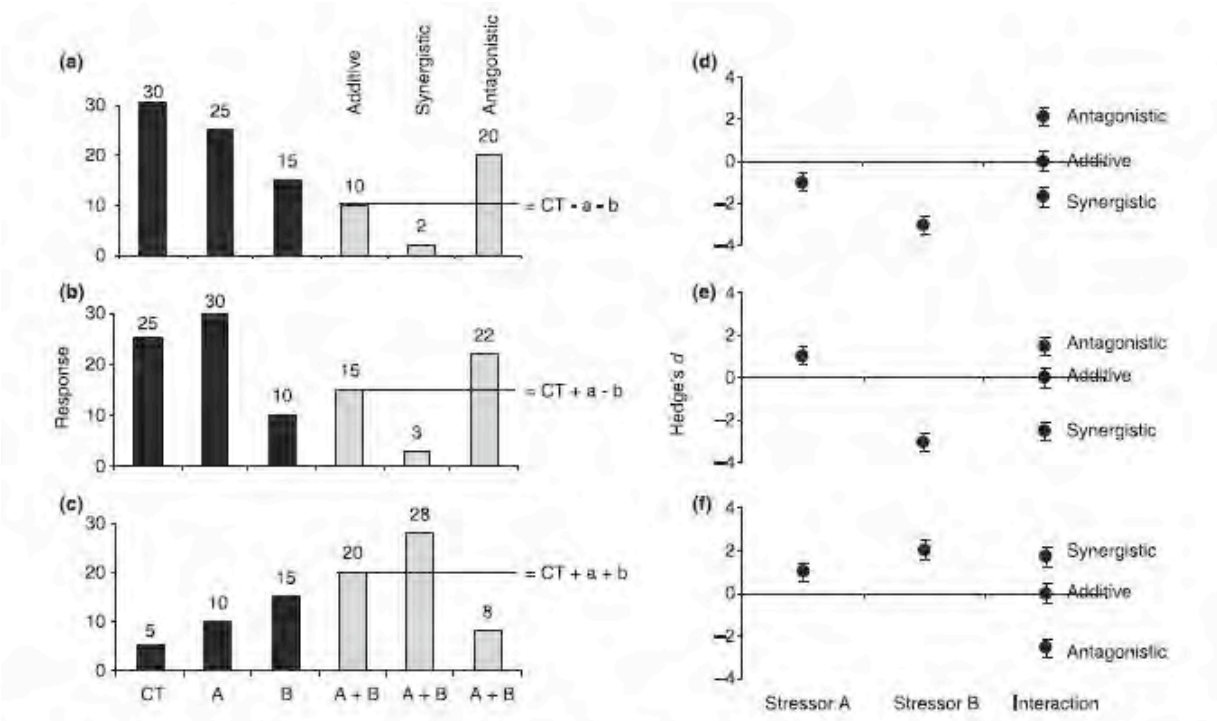


Figure 1 Conceptual approach to interpreting interaction types from population or community response data presented in factorial studies (a–c) and corresponding individual and interactive effect sizes measured with Hedge's *d* (d–f) before combining across studies using meta-analysis. Treatments in factorial studies include control (CT), with stressor A (A), with stressor B (B), and with both stressors (A + B). Interaction types (additive, synergistic and antagonistic) vary depending on A + B response and are illustrated here for stressors that have double negative (a and d), opposing (b and e), and double positive (c and f) main effects on the response variable of interest.

In practice, cumulative effects are determined by calculating an interactive effect-size index. Two common effect-size indices are Hedges *d* (Hedges and Olkin 1985, Fig 1D-F) and the response ratio (Hedges et al. 1999, Darling et al. 2008). Significant interactive effects (i.e., synergistic or antagonistic effects) are those in which the chosen confidence interval of the given effect size does not overlap the pre-determined value of an additive effect size (Fig. D-F). Effect-size indices from individual studies can then be combined using meta-analysis in order to summarize results across multiple studies (Hedges and Olkin 1985).

Two other models of cumulative effects have been described: multiplicative, where the combined effects are expected to be the product of the individual stressors' effects; and comparative, where one stressor primarily drives the response (Folt et al. 1999). An additive model is often used to categorize the cumulative effects of multiple anthropogenic stressors because the null hypothesis is the simplest combination of effects from which we can test for deviations. Additionally, an additive

model underlies the ANOVA framework used in factorial experiments, comparable analyses and applications (Halpern et al. 2008, Crain et al. 2008, Darling et al. 2008).

References

Crain CM, Kroeker K, Halpern B (2008). Interactions and cumulative impacts of multiple stressors in marine ecosystems. Ecol. Lett. 11:1304-1315

Darling ES, Cote IM (2008) Quantifying the evidence for ecological synergies. Ecol. Lett. 11: 1278-1286

Folt CL, Chen CY, Moore MV, Burnaford J (1999) Synergism and antagonism among multiple stressors. Limnol Oceanogr 44:864–877

Halpern B, Walbridge S, Selkoe K, Kappel C, Micheli F, D'Agrosa C, Bruno J, Casey K, Ebert C, Fox H, Fujita R, Heinemann D, Lenihan H, Madin E, Perry M, Selig E, Spalding M, Steneck R, Watson R (2008) A global map of human impact on marine ecosystems. Science 319: 948-952

Hedges LV, Gurevitch J, Curtis PS (1999). The meta-analysis of response ratios in experimental ecology. Ecology, 80, 1150–1156

Hedges LV, Olkin I (1985). Statistical methods for meta-analysis. Academic Press, New York, New York, USA

7. Quantifying Cumulative Risk to Populations

7.1 *Managing marine mammal populations in the U.S.*

Barbara Taylor
Southwest Fisheries Science Center, NOAA Fisheries Service

The Potential Biological Removal (PBR) management system was created to manage direct mortalities in fisheries, which was the primary threat to marine mammals in U.S. waters in the 1990s. Review of why and how this transparent system was developed provides an example of a process that uses a minimal amount of data, directly incorporates uncertainty and relies on quantitative objectives. Since new threats have developed (including ocean noise), data obtained for the PBR system were used to address the question: "For what proportion of stocks could we detect precipitous declines (50% decline in 15 years assuming a = 0.05)?" The statistical power to detect such a decline is near zero for beaked whales, which was not surprising. However, a power of only 30% to detect such a decline for large whales was a surprise and is a sobering value for assessing cumulative effects of numerous potentially small indirect effects. Risk assessment for demographically independent populations often relies on estimates of trends in abundance. Given the poor ability to detect precipitous declines using traditional statistical significance criteria, an alternative method using Bayesian methods is given to provoke discussion of possible extensions to a PBR-like approach that consider more than direct human-caused mortality.

7.2 Managing cumulative impacts and uncertainty

Michael Bode
Applied Environmental Decision Analysis Group
The University of Melbourne

Uncertainty is an ever-present concern when managing wild populations (Williams 2001; Hauser *et al.* 2007). When considering the impacts of underwater noise on marine mammals – a group of species with long generation times, difficult to observe lifestyles, and highly-evolved behavioral responses – this uncertainty is greatly amplified. Some aspects of this management question are understood, for example, the physical processes of underwater sound generation and propagation. There is also no doubt that on an individual level, certain forms of noise have been shown to cause

considerable physiological and behavioral stress (Jepson *et al.* 2003; Morton & Symonds 2004). However, estimating the cumulative impact of anthropogenic noise on a population of marine mammals depends on a suite of highly uncertain factors. It is unclear precisely how most types of noise injure or alter the behaviour of marine mammals. Further, researchers cannot confidently predict the consequences of these immediate, individual-scale impacts on long-term population-scale attributes, such as demographic structure or growth rates (NRC 2005). The practicalities of management further complicate the treatment of uncertainty in two important ways. First, the research resources available to reduce this multi-faceted uncertainty are very limited, particularly compared to the prohibitive costs of gathering data on appropriate spatial and temporal scales. Second, much of the potentially threatening anthropogenic noise is generated by critical economic and political forces, including international trade, geophysical exploration, and the military (NRC 2003). Political institutions may need to be particularly confident that a given activity is having biologically significant effects before they will implement constraints. The required level of confidence required to instigate changes may therefore depend on the threatening process.

In such complex ecosystems, decision-making can only be efficient and transparent with the support of quantitative models that explicitly incorporate uncertainty (Wintle 2007). Decision-theory approaches to uncertain management problems have become best-practice for conservation in the terrestrial environment (e.g., Margules & Pressey 2000), but many are actually extensions of innovations that originated in fisheries management (e.g., Clark 1990). I will discuss two important aspects of management in uncertain conservation systems. The first is the range of methods available for coherently incorporating uncertainty into ecological models and decision-support tools. A suite of different approaches exist for this purpose, each of which is appropriate when different amounts of information are available, ranging from parameterized risk through to severe uncertainty (Regan *et al.* 2005). The second issue is located at the interface between ecology and management: how should the decision-focus of management influence our attitudes towards uncertainty. In contrast to ecological research, conservation management is primarily concerned with making efficient decisions. Understanding ecological processes, and accurately predicting future dynamics, are only important insofar as they improve management objectives. When the focus is shifted from science to decision-making, our attitude towards uncertainty is fundamentally altered. Some level of uncertainty is not just tolerated by conservation, it is actually optimal. Additional research will not necessarily improve outcomes, if it requires the investment of resources and time that could be invested in management actions (Grantham *et al.* 2009*a*,*b*). The best focus for research may not necessarily be the most uncertain aspects in the ecosystem, nor the most sensitive. Instead, research attention should be decided by the highly variable costs of different ecosystem components, and by the expected impact of reduced uncertainty on manager's decisions (Baxter *et al.* 2006).

References

Baxter, P.W.J., McCarthy, M.A., Possingham, H.P., Menkhorst, P.W., McLean, N. (2006). Accounting for management costs in sensitivity analyses of matrix population models. *Conservation Biology* 20, 893–905.

Clark, C.W. (1990). *Mathematical bioeconomics: optimal management of renewable resources.* Wiley & Sons, New Jersey.

Grantham, H.S., Moilanen, A., Wilson, K.A., Pressey, R.L., Rebelo, T.G., Possingham, H.P. (2009*a*). Diminishing returns on investment for biodiversity data in conservation planning. *Conservation Letters*, 1, 190–198.

Grantham, H.S., Wilson, K.A., Moilanen, A., Rebelo, T.G., Possingham, H.P. (2009b). Delaying conservation actions for improved knowledge: how long should we wait? *Ecology Letters*, 12, 293–301.

Hauser, C.E., Runge, M.C., Cooch, E.C., Johnson, F.A., Harvey, W.F. (2007). Optimal control of Atlantic population Canada geese. *Ecological Modelling*, 201, 27–36.
Jepson, P.D., Arbelo, M., Deaville, R., *et al.* (2003). Was sonar responsible for a spate of whale deaths after an Atlantic military exercise? *Nature*, 425, 575–576.
Margules, C.R., Pressey, R.L. (2000). Systematic conservation planning. *Nature*, 405, 243–253.
Morton, A.B., Symonds, H.K. (2004). Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia, Canada. *ICES Journal of Marine Science*, 59, 71–80.
National Research Council (2003). *Ocean Noise and Marine Mammals.* The National Academies Press, Washington DC.
National Research Council (2005). *Marine Mammal Populations and Ocean Noise.* The National Academies Press, Washington DC.
Regan, H.M., Ben-Haim, Y., Langford, B., Wilson, W.G., Lundberg, P., Andelman, S.J., Burgman, M.A. (2005). Robust decision-making under severe uncertainty for conservation management. *Ecological Applications*, 15, 1471–1477.
Williams, B.K. (2001). Uncertainty, learning and the optimal management of wildlife. *Environmental and Ecological Statistics*, 8, 269–288.
Wintle, B.A. (2007). Adaptive management, population modeling and uncertainty analysis for assessing the impacts of noise on cetacean populations. *International Journal of Comparative Psychology*, 20, 237–249.

7.3 Determining population risks under cumulative threats

Justin G. Cooke
Centre for Ecosystem Management Studies
Alexanderstr. 10, 79261 Gutach, Germany; Email: jgc@cems.de

Marine mammal populations are subject to an increasing range of anthropogenic threats throughout their range. Two key issues in managing these threats and their impacts are: (i) the empirical detection and measurement of effects of single or cumulative adverse factors on marine mammal populations; and (ii) the prediction and estimation of the expected population consequences of different future levels of specific adverse factors. The two issues are related, because generally one relies on the detection of impacts in at least some cases in order to quantify by analogy (albeit with low precision) the possible impacts of comparable factors on the same or other populations.

The prospects for determining the effects on populations of single or cumulative threats depend strongly on the nature of the expected impact and the kind of population monitoring that is in place or could be implemented.

The kinds of impact that, depending on the threat, need to be detected and measured, include:
(i) immediate: mortality events in close temporal and spatial proximity to the causal event;
(ii) short-term: extra mortality or diminished reproduction in the same or following year to the causal event;
(iii) medium or long-term reduction in survival or reproductive rate.

The kinds of monitoring that are or can be implemented include: monitoring levels of population abundance; monitoring of distribution; direct observation of mortality; indirect estimation of mortality from survival analyses; observation of reproductive success from direct counts of calves/pups or from calving/pupping intervals; observation of physical or biochemical indicators of body condition or pathology.

The feasibility or utility of each kind of monitoring, expressed in terms of precision information gained for a given level of research effort, depends on the characteristics of the species and

population. Tables can be constructed for each species showing the power to detect different kinds of impact from each type of monitoring.

Reduction in abundance at the population level, and indirect evidence of enhanced mortality from survival analyses, can typically only be detected after a considerable period and when the reduction has become severe; the power to link the change to a specific cause is low. Provided the causal factors are sufficiently variable and their effect is immediate or short-term, direct observations of mortality, reproduction and body condition factors offer greater power to detect and identify certain kinds of impact.

As a worked example of the approach, this analysis is applied to the Critically Endangered western population of gray whales (*Eschrichtius robustus*) which is subject to threats from petroleum-related operations, including seismic surveys, in the prime feeding habitat for mothers and calves, by-catch in fishing nets on its migration route, and possible additional adverse factors on its still undiscovered breeding grounds.

Where there are grounds for concern about the impact of a potentially adverse factor that is being introduced into the marine environment, it is essential that appropriate monitoring programmes for the potentially affected marine mammal populations, tailored both to the characteristics of the populations and to the nature of the threats, are implemented at an early stage. Otherwise, impacts may go undetected for a long period until severe damage to the population has been inflicted.

8. Quantifying Cumulative Risk to Ecosystems

8.1 Tools for large scale (ecosystem-based) and long-term (evolutionary) environmental risk assessment in the marine environment

Marc Mangel & Will Satterthwaite
Center for Stock Assessment Research, Department of Applied Mathematics and Statistics
University of California, Santa Cruz

Even after the potential physiological impacts of an environmental change on individuals have been identified, scaling these impacts up temporally (to evolutionary time periods) and spatially (to the ecosystem level) remains a challenging task. We lay out a conceptual framework within which established effects of environmental conditions on individual physiology can be scaled up to make broader predictions. Models can link changes in individual physiology to predictions about individual behavior, which interact with natural selection to create changes in distribution and abundance in space and time. We describe these linkages and the prediction of impacts at multiple scales, using examples drawn from work by our lab group and collaborators. By showing examples of these tools in action, we hope to provide guidance for applying this framework to the marine noise problem. For example, noise pollution might affect the distance at which foraging marine mammals can detect their prey, which would be predicted to reduce encounter rates, and the magnitude of this effect can be modeled on a mechanistic basis (Gerritsen and Strickler 1977). According to classic rate-maximizing models of diet choice (Mangel 1996, Mangel and Wolf 2006), this may lead to a broader diet. More sophisticated state-dependent behavioral models (Clark and Mangel 2000, Cresswell et al. 2008, Satterthwaite et al. 2009) may additionally predict changes in time budgets, energy allocation, and total consumption; and provide a means to link these changes to reproductive success. These changes in diets and reproductive success can be used to predict trends in population size using demographic models (Caswell 2001, Finkelstein et al. 2008, Wiedenmann et al. 2008) and to predict changes in community composition using ecosystem models (Christensen and Walters 2004, Aydin et al. 2007). Changes in community composition may feed back to the individual and

population level by changing prey availability and thus potentially altering consumption, diet choice, and reproductive success (Mangel and Wolf 2006).

To achieve stakeholder buy-in, model predictions should be presented with some measure of associated uncertainty, and alternative models should be allowed to compete (Wolf and Mangel 2008). With complicated models of this sort, traditional statistical approaches can be inappropriate to apply and/or difficult to interpret. Numerous promising alternatives are available. Simple sensitivity analyses (Satterthwaite et al. 2009) are computationally straightforward means of summarizing the effects of uncertainty in key variables within a given model structure. When comparing how well multiple model formulations can explain existing data, information-theoretic model comparison tools (Burnham and Anderson 2002) provide an established framework for trading off the increased fit made possible by a more complicated model against the associated risk of increased bias. Bayesian statistics (McCarthy 2007) provide a tool for making use of existing prior knowledge, combining the information gained through multiple studies, and making probabilistic statements that can incorporate multiple sources of uncertainty.

References

Aydin, K., S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday. 2007. A comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands large marine ecosystems through food web modeling. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-178.

Burnham, K. P. and D. R. Anderson. 2002. Model Selection and Multimodel Inference: A Practical Information-Theoretical Approach. 2d ed. Springer-Verlag, New York.

Caswell, H. 2001. Matrix Population Models: Construction, Analysis, and Interpretation. Second edition. Sinauer Associates, Sunderland MA.

Christensen, V., and C. Walters. 2004. Ecopath with Ecosim: methods, capabilities, and limitations. Ecological Modelling 172:109-139.

Clark, C.W. and M. Mangel. 2000. Dynamic State Variable Models in Ecology. Methods and Applications. Oxford University Press, New York.

Cresswell, K. A., Wiedenmann, J. and Mangel, M. (2008) Can macaroni penguins keep up with climate- and fishing-induced changes in krill? Polar Biology 31:641-649.

Finkelstein, M., V. Bakker, D. F. Doak, B. Sullivan, W. H. Satterthwaite, R. Lewison, P. B. McIntyre, S. Wolf, D. Priddel, J. M. Arnold, R. W. Henry, P. Sievert, and J. Croxall. 2008. Evaluating the potential effectiveness of compensatory mitigation strategies for marine bycatch. PLoS One 3(6): e2480 doi:10.1371/journal.pone.0002480

Gerritsen, J. and J. R. Strickler. 1977. Encounter probabilities and community structure in zooplankton: a mathematical model. Journal of the Fisheries Research Board of Canada 34:73-82.

Mangel, M. 1996. Rate maximizing and state variable theories of diet selection. Bulletin of Mathematical Biology 54:413-422.

Mangel, M. and N. Wolf. 2006. Predator diet breadth and prey population dynamics. pp. 279-285 in Whales, Whaling, and Ocean Ecosystems (JA Estes, DP Demaster, DF Doak, TM Williams and RL Brownell, Jr. editors). University of California Press, Berkeley.

McCarthy, M. 2007. Bayesian methods for ecology. Cambridge University Press, Cambridge, UK.

Satterthwaite, W. H., M. P. Beakes, E. Collins, D. R. Swank, J. E. Merz, R. G. Titus, S. M. Sogard, and M. Mangel. 2009. Steelhead life history on California's central coast: insights from a state dependent model Transactions of the American Fisheries Society 138: 532-548.

Wiedenmann, J., Cresswell, K. A. and Mangel, M. 2008. Temperature-dependent growth of Antarctic krill: predictions for a changing climate from a cohort model Marine Ecology Progress Series 358: 191-202.

Wolf, N. and M. Mangel. 2008. Multiple hypothesis testing and the declining-population paradigm in Steller sea lions. Ecological Applications 18:1932-1955.

8.2 Implementing ecosystem-based management via marine spatial planning: Reducing cumulative impacts on marine mammals

Larry B. Crowder
Center for Marine Conservation, Duke University

Marine mammals once dominated ocean ecosystems now increasingly dominated by human activities. Here I briefly review the role of marine mammals in the structure and functioning of marine ecosystems, the declining influence of marine mammals on marine food webs, and the role of cumulative impacts on their functional role in these systems. We understand the vital rates that influence the health of marine mammal populations, but we understand little about the vital rates of a healthy marine ecosystem. What role do marine mammals now play in marine ecosystems? What role would we like them to play? How do we transition from where we are now to where we would like to be? In response to such specific problems, the scientific community has called for a transition from traditional population-level management to ecosystem-based management. The way to implement marine ecosystem-based management is likely to include marine spatial planning. In this talk, I will provide an overview of the MSP process with special reference to reducing conflicts between marine mammals and human activities.

9. Potential new tools in the management of cumulative impacts in marine mammals

9.1 Network theory and its potential for use in understanding and managing cumulative and synergistic impacts

Jose Javier Ramasco

Networks have recently shown to be useful tools for understanding and characterizing complex systems. Systems that can be analyzed using network models (called ‘graphs’) include the following examples: the description of social groups; the study of Internet; and the spread of disease. The basic elements of the system, such as people, animals, populations, etc, can be represented as nodes and their relations as links. The spreading of a disease, information or contaminant thus follows the subtract (i.e., the flow follows the structure of contacts dictated by the network connections) established by the graph, while social processes such as group fission or fusion correspond to the dynamical aspects of the network (see for instance Albert02, Newman03, Pastor04, Dunne06, Barrat08).

The application of complex networks to social systems has a long tradition, going back a little more than half a century (Freeman 04). Some of these results can be extrapolated to communities of social animals and their dynamics. Complex networks have been also employed to describe food-webs and food-chains, which are important for describing how some pollutants such as heavy metals propagate in the ecosystem. They are also essential to model infectious disease propagation. In my presentation, I will summarize previous results and will aim to propose topics and examples that could be of interests for the study of anthropogenic impacts on marine mammals. The hope is to facilitate future interdisciplinary collaborations.

References

(Albert02) R. Albert and A.-L. Barabasi, Statistical mechanics of complex networks, Rev Mod Phys} 74:47-97 (2002).
(Newman03) M.E.J. Newman, The structure and function of complex networks, SIAM Reviews 45:167-156 (2003).

(Pastor04) R. Pastor-Satorras and A. Vespignani, Evolution and structure of the Internet : a statistical physics approach, Cambridge Univ. Press (2004).

(Dunne06) J.A. Dunne, The network structure of foodwebs, in Ecological Networks: Linking Structure to Dynamics in Food Webs. M. Pascual and J.A. Dunne, eds. Oxford University Pres (2006).

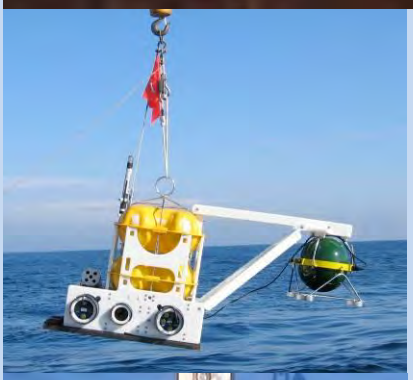
(Barrat08) A. Barrat, M. Barthelemy and A. Vespignani, Dynamical Processes on Complex Networks, Cambridge Univ Press (2008).

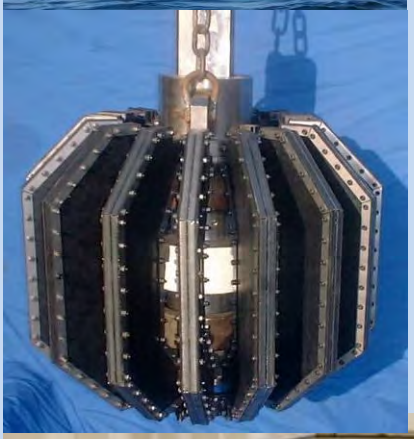
(Freeman04) L.C. Freeman, The Development of Social Network Analysis: A Study in the Sociology of Science, Empirical Press (2004).

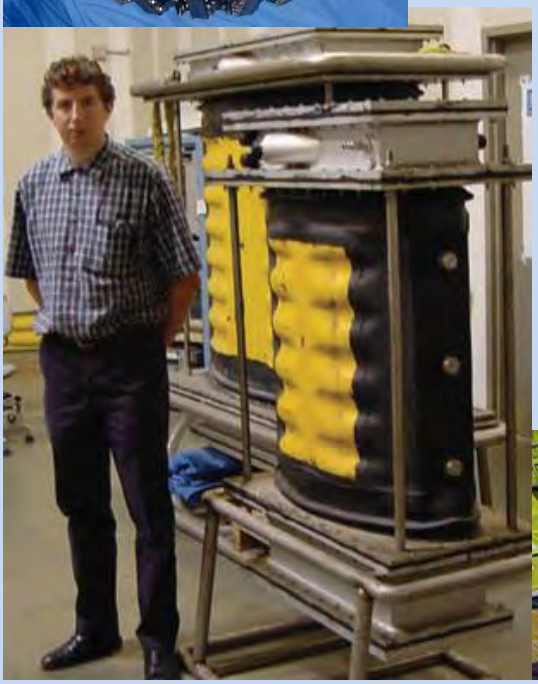
STIFTUNG FÜR DAS MEER
okeanos

okeanos - Stiftung für das Meer
Auf der Marienhöhe 15
D-64297 Darmstadt
Telefon +49- 6151-918 20 23
Telefax +49- 6151-918 20 19
mail@okeanos-stiftung.org
www.okeanos-stiftung.org

Courtesy of
Bjørge Naxys







REPORT OF THE WORKSHOP ON

ALTERNATIVE TECHNOLOGIES TO SEISMIC AIRGUN SURVEYS FOR OIL AND GAS EXPLORATION AND THEIR POTENTIAL FOR REDUCING IMPACTS ON MARINE MAMMALS

Held by Okeanos - Foundation for the Sea
Monterey, California, USA

31st August – 1st September, 2009

Edited by

Lindy Weilgart, Ph.D.

March, 2010

okeanos - Stiftung für das Meer
Auf der Marienhöhe 15
D-64297 Darmstadt
Telefon +49- 6151-918 20 23
Telefax +49- 6151-918 20 19
mail@okeanos-stiftung.org
www.okeanos-stiftung.org

Weilgart, L.S. (ed) 2010. Report of the Workshop on Alternative Technologies to Seismic Airgun Surveys for Oil and Gas Exploration and their Potential for Reducing Impacts on Marine Mammals. Monterey, California, USA, 31st August – 1st September, 2009. Okeanos - Foundation for the Sea, Auf der Marienhöhe 15, D-64297 Darmstadt. 29+iii pp. Available from http://www.sound-in-the-sea.org/download/AirgunAlt2010_en.pdf

Contents

Prologue ii

Consensus Summary 1

Additional Notes/Information: 5

Table 1. Characteristics of various technologies used to image the ocean substrate for petroleum deposits. 11

Table 2. Applications of various technologies used to image the ocean substrate for petroleum deposits. 13

Table 3. Characteristics of various types of seismic surveys and imaging technologies. 14

Participants 15

Presentation Abstracts 16

An Overview of the Uses of Sound by Marine Mammals and the Impacts from Anthropogenic Underwater Noise Sources 16

Biological Implications of Chronic Exposure from over Large Spatial Scales: Seismic Surveys 17

Impacts of Airguns on Marine Animals: Thresholds for Injury and Behavioral Alterations 18

Marine seismic surveys for science: Purpose, operation and product 18

How Seismic Data Is Used By the Petroleum Industry 19

The potential for reducing unnecessary horizontal and high frequency components of sound produced by airguns 20

A Deep Water Resonator Seismic Source 21

Potential application of 3D EM methods to reduce effects of seismic exploration on marine life 22

Vibroseis Technology 23

Low frequency passive seismic for oil and gas exploration and development: a new technology utilizing ambient seismic energy sources 24

Passive Seismic Tomography: structural imaging using natural sources 25

The dBht Method for Evaluating Impact, Airgun Silencers and LF Projector Arrays 26

Fibre optic receivers and their effect on source requirements 27

Alternatives to Acoustic (Seismic) Geophysical Data Collection 28

Prologue

By Dieter Paulmann

As part of our continuing efforts to preserve the oceans and their inhabitants, we, Okeanos – Stiftung für das Meer (Foundation for the Sea), have focused on the issue of anthropogenic (human-made) underwater noise and its impact on marine mammals. Okeanos has held a number of international, multi-disciplinary workshops on various novel aspects of this issue, ranging from noise-induced stress effects, and noise management through spatial planning, to ship-quieting technologies, and techniques for assessing the cumulative impacts of underwater noise together with other anthropogenic stressors facing marine mammals. Fruitful, productive discussions and collaborations, especially between experts from diverse fields that don't commonly interact, have resulted from these workshops. Scientists from a diversity of disciplines and specialties (ranging from biologists to engineers) and policy makers, working together, have managed to merge their expertise to develop new ideas, techniques, and mechanisms for making progress on the science and management of ocean noise.

One such management mechanism to reduce ocean noise is source-based mitigation, i.e. making sound sources more benign to marine mammals. Seismic airgun surveys, including those used in the exploration of oil and gas deposits underneath the ocean floor, produce loud, sharp impulses that can raise noise levels substantially over large areas. These surveys can last for months and the noise they produce is virtually ubiquitous in the world's oceans. Though noise impacts on marine life (fish and even invertebrates, along with marine mammals) from seismic surveys are well documented, the biological relevance of these impacts on wild populations remains controversial among the various stakeholders. Rather than address the controversy or evaluate the evidence for or against impact, our purpose in this workshop was to examine quieter, potentially less harmful technologies that might be able to, at least partially, replace airguns. While airguns are excellent tools to image formations, structures, and deposits deep in the ocean substrate, they also have drawbacks from an engineering/industry point of view. They produce more noise than is needed for hydrocarbon exploration, the signal is not very repeatable or controllable, and the frequencies produced are not as low as are sometimes necessary for good penetration of the substrate. In the same way that, historically, airguns replaced explosives for oil and gas exploration because airguns were safer for humans, it is perhaps now time for airguns themselves to evolve into technologies that are more environmentally sensitive and perhaps even more effective in finding oil and gas deposits.

To this end, and supported by the Okeanos Foundation, an international, multi-disciplinary group of geophysical scientists, seismologists, biologists, and regulators met in Monterey, California, 31 August-1 September, 2009, to seek alternatives and/or modifications to airguns and airgun array configurations in order to minimize their potential impacts. Participants were asked to evaluate the strengths and limitations of various alternative/supplementary technologies, consider the conditions under which each could be applied, and discuss aspects such as the timeframes over which they would be commercially available, if not in use presently. Only participants with expertise in a particular alternative technology or airgun array configuration were invited, along with marine mammal biologists. The goal was to preferentially eliminate the use of sound for hydrocarbon exploration, or to reduce the amount or type of potentially harmful acoustic energy introduced, or the total area ensonified.

On the first day, each participant gave a presentation, generally about the technology in which they specialize. These technologies were then discussed on the second day, and a consensus summary statement was formulated by the group. This report consists of that summary statement, along with some supplementary notes by various participants, and three tables on seismic survey characteristics, applications for airgun alternatives, and characteristics of airgun alternatives, respectively.

Discussions were extremely collegial, and there was little disagreement on the main points, namely that:

- airguns produce "waste sound" that is not used by the industry, yet has the potential to impact marine life;
- that this sound (mainly high frequencies and lateral propagation) could be eliminated without sacrificing any data quality for the hydrocarbon industry;
- that reducing peak sound levels is a worthwhile goal even at the expense of requiring a slightly longer signal;
- that technologies are available or emerging that do not introduce any anthropogenic sound, or introduce substantially less sound, into the environment;
- that less sound may be required to gather the same quality of data due to more sensitive receivers;
- and, finally, that regulatory pressure/incentives and more funding to develop these technologies will expedite their availability and broaden their applications.

As the ever-expanding search for petroleum deposits moves towards deeper water (possibly requiring a louder signal) and more sensitive habitats, such as the Arctic, the need for more benign alternatives to airguns will escalate. Nevertheless, in some particularly vulnerable, critical, and productive habitats, any addition of noise may be too much. Moreover, alternatives that are assumed to be more environmentally benign than airguns, may in fact not be. Quieter is almost always better, but all alternatives should be assessed for their environmental impact before being put to wide use. This report is not meant to advocate any alternatives without such essential prior testing.

Some of the information contained within this report is somewhat preliminary in nature. There is still much research and development that needs to be done on some alternatives to seismic airguns. However, this report should dispel any doubts that substantial improvements can be made, even in the near future. What is mainly lacking is regulatory pressure as well as funding. This report seeks to stimulate debate and interest from companies, which in some cases are already developing alternatives to airguns, and policymakers.

This report also includes lists of participants and their presentations, the latter with abstracts.

Dieter Paulmann
Founder, Okeanos - Stiftung für das Meer (Foundation for the Sea)
Auf der Marienhöhe 15, D-64297 Darmstadt, Germany
www.okeanos-stiftung.org

Consensus Summary

of the
Workshop on Alternative Technologies to Seismic Airgun Surveys for Oil and Gas Exploration and their Potential for Reducing Impacts on Marine Mammals

Lindy Weilgart (ed. and co-organizer of the workshop), Andrew Wright (co-organizer of the workshop), Leila Hatch (chair)

Participants (alphabetically): Ron Brinkman, MMS; Chris Clark, Cornell University; John Diebold, LDEO; Peter Duncan, Microseismic Inc.; Rob Habiger, Spectraseis AG; Leila Hatch, NOAA; John Hildebrand, Scripps Institution of Oceanography; Phil Nash, Stingray Geophysical Ltd.; Jeremy Nedwell, Subacoustech; Dave Ridyard, EMGS; Rune Tenghamn, PGS; Peter van der Sman, Shell; Lindy Weilgart, Dalhousie University; Warren Wood, NRL; John Young, ExxonMobil

Abstract

Past experience shows us that a fraction of the airgun sound that has potential to impact marine mammals (either physically or behaviorally) comes from "waste sound" that is either too high frequency and filtered out before recording or propagates laterally away from receivers and is also never recorded. The Okeanos Seismic Airgun Alternatives workshop panelists identified several ways in which unwanted sound or noise from seismic airguns might be reduced with little or no effect on the quality of data acquired. In addition to eliminating this noise or unused signal, peak sound levels required for exploration might also be reduced by spreading the source energy out over time, and/or moving sources and receivers closer to the seafloor. Panelists also discussed promising new imaging technologies that are either completely silent (e.g. controlled source electromagnetics) or that can lessen the amount of seismic sound required to gather seismic data (e.g. increasing the density of more sensitive receivers, such as fiber optics or through the use of passive seismic technology) thereby still allowing for a reduction of the economic risk of hydrocarbon recovery. Workshop panelists acknowledged that these technologies are purpose driven and do not work in all circumstances. Many of these technologies may be either available now or in the next 1-5 years, depending on funding and technology advancements.

Introduction

Supported by Okeanos, a multi-disciplinary group of geophysical scientists, seismologists, biologists, and regulators met to seek ways to reduce noise from seismic airgun surveys, specifically the large airgun arrays used for oil and gas operations in the ocean. We, the participants of this unique gathering, agree that marine life would benefit from a quieter ocean. With the introduction of new technologies and techniques, turning the tide on rising levels of noise in the oceans now seems feasible. The following findings and recommendations represent the key results of our discussions at the workshop.

Findings and Recommendations

The most effective acoustic mitigation remains not exposing marine life (i.e., through avoidance) to additional anthropogenic noise.

- Government agencies responsible for regulating offshore seismic data acquisition activities (hereafter: 'Regulators') should collect or fund collection of baseline data on the distribution of marine mammals in space and time in areas where seismic data acquisition is being planned. These data should be collected as far in advance of the seismic data acquisition as is practicable (especially where species distribution is poorly understood or in areas where seismic data acquisition is new).
- In areas where seismic data acquisition will take place and is likely to expose marine animals to noise, efforts should be made by regulators in conjunction with the operator of the seismic data acquisition activity to reduce sound levels to the lowest practicable and/or integrate the use of alternative technologies into planned activities to reduce noise exposure.
- Impulsive sources like airguns have the potential to physically impact marine life because of the sharp rise times and high peak pressures of airguns. Behavioural effects are also possible due to exposure to sound at distances away from the airguns.
- A multi-dimensional metric or scoring system to quantify the impacts of airguns or alternatives on various marine animals would be very helpful, though difficult.

Airguns

- Airgun design can be optimized to reduce unwanted energy.
    - Imaging deep geological targets requires an acoustic source outputting relatively low frequency content (<200Hz). The lower frequencies provide the deep energy penetration into the earth. Currently seismic airguns produce broad-band acoustic energy (>200Hz) and in directions (both inline and horizontal to the plane of interest) that are not of use. During collection of seismic data for deep imaging purposes one should strive to reduce unnecessary acoustic energy (noise) through array, source, and receiver design optimization. A more general statement can be made that regardless of the imaging target, anyone collecting seismic data should strive to reduce unwanted energy or noise. It should be noted that even if unwanted frequencies (> 200 Hz) are removed, there will still be frequency overlap with several marine animals (including most baleen whales) that can and should be minimized.
- Lower source levels could be achieved through better system optimization, i.e. a better pairing of source and receiver characteristics, and better system gain(s). For example, new receiver technologies, such as fibre optic receivers, may allow the use of lower amplitude sources through a higher receiver density and/or a lower system noise floor.
- Some evidence exists which indicates that re-engineered air guns with "mufflers" can be used to attenuate unwanted high frequency energy without affecting frequencies of interest.
- Bubble curtains may be used to optimize the directivity of the source, but they can be difficult to use, produce some noise themselves, and cannot fully eliminate horizontal propagation.

Use of alternative technologies with airguns and/or instead of airguns

Controlled sources generally put the same level of geophysically useable energy into the water as impulsive sources like airguns, but over a longer period of time, and a resulting lower peak sound level, i.e. they are quieter. For example, for a rough calculation in the near-field, a one-second oscillatory/vibrator/projector pulse puts the same level of geophysically useful energy into the water as an airgun's ten millisecond pulse, but is one-hundred times quieter, resulting in a ten-thousand fold reduction in the area of ensonification. These sources include technologies such as the electro-mechanical modern marine vibrator, low frequency acoustic projector (driving cylinder, e.g. LISA, a low frequency electromagnetic transducer system), the solid state piezo-ceramic Helmholz resonator (e.g. The Naval Research Laboratory's DTAGS), and other non-impulsive, oscillating sound sources. Furthermore, controlled sources can produce sound over the frequency range desired, generating signals that can be specifically designed to minimize the impact on marine mammals and maximize geological interpretability (e.g. pseudo-random sequences).

It has been suggested that masking, or the obscuring of signals important to marine life, may worsen over this smaller ensonified area, because of the more continuous nature of the vibratory source. However, airguns at distance, especially in a reverberant environment, permanently raise the noise floor, as the previous pulse does not decay fully to background noise levels before the next shot is fired. Thus, airgun shots do not represent truly intermittent signals, with gaps of silence between shots. To better understand the environmental advantages or disadvantages of the use of controlled acoustic sources will require further research.

Controlled sources, such as marine vibrators (e.g., hydraulic, electric, etc.), offer the opportunity to reduce the peak amplitudes introduced into the water column and to tune the frequencies transmitted to exactly the band-width required for operations. By using a sweep instead of an impulse source, one can reduce the amplitude (peak levels) by 30 dB. This is done by spreading out the energy over time. A sweep that is 10 s has the same amplitude after correlation that a short 40 ms pulse generated by the airgun has. The use of pseudo noise (PN) sequences could reduce the acoustic footprint further (perhaps by an additional 20 dB/Hz by spreading out frequencies over time), but more research is needed to fully understand how to implement these sequences in an effective and optimized way.

- There is some evidence that a swept signal with lower peak amplitude would have less impact on marine animals than a higher peak impulsive signal. It is possible that pseudonoise sequences would reduce impacts further than normal up or down sweeps as they would sound broadly similar to natural background noise--noise to which such animals would presumably be adapted. More research is needed to assess this.
- In certain situations and with certain non-airgun source types, placing the sources and/or receivers near or on to the sea floor can reduce the required source level, as well as the amount of sound that needs to travel through the water column. For example, marine vibrators can operate close to the sea-bed and accomplish increased penetration relative to shallow towing.
- A controlled source offers improved receiver optimization possibilities compared to airguns. For instance, a combination of fiber optic sensors with a reduced bandwidth seismic source, such as a marine vibrator, may make the most optimal use of these technologies.
- Marine vibrators also have the advantage of being more vertically directional in deeper water.
- Front-loading the exploration workflow with the use of silent technologies (e.g., CSEM / 3D EM, gravity, gravity gradiometry, etc.) has potential to optimize the exploration process and require

less sound to be injected into the environment. For instance, if 2D airgun surveys followed by quieter technologies (e.g. 3D CSEM) do not show promising targets, proceeding with 3D seismic surveys may not be worthwhile. Conversely, one may optimize 3D seismic activities based on the results from 2D seismic and 3D CSEM.

- Technologies such as marine vibrators, microseismic monitoring (passive seismic), and fiber optics have potential to reduce the need for 4D airgun surveys, used to monitor the movement of oil or gas in an exploited reservoir over time.
- Regulators and/or the geological and geophysical industry (including oil and gas exploration and production companies) should fund or undertake research into impacts on marine animals of alternative technologies such as marine vibrators and CSEM / 3D EM surveys. Companies developing these technologies need to work together with marine biologists to better understand, design, and carry out research needs in this area.
- While some airgun alternative technologies are available now or in the next 1-5 years (see Table 1), an increase in R&D funding for alternative exploration technologies (e.g., CSEM / 3D EM, marine vibrators, passive seismic, fibre optics receivers, etc.) will accelerate development and expand the application window. Governments should encourage the development and use of alternative technologies in an environmentally sensitive manner through both regulatory changes as well as additional funding to regulatory bodies, scientists, and engineers.

Coordination / Incentives

- Regulators should fund or undertake efforts to produce higher quality, accessible, and well-managed databases for marine animal distribution in space and time, which are needed to inform environmental impact assessments. Note: The Minerals Management Service (MMS) is data basing all current marine mammal observer sighting records and, although presently not a requirement, is encouraging the use of Passive Acoustic Monitoring (PAM) for future surveys.
- Efforts should be made to characterize the current (snap-shot in time) spatial distribution and other characteristics of noise exposure from airgun use in worldwide waters (centralize data on incidence of different uses and locations/regional use). Good measurements of the frequency content of seismic airgun pulses at various depths and ranges should be made.
- Holders of geological and geophysical data should mine their data to more fully characterize what is known about where airguns were used, what their output characteristics were, and any related propagation information that is available. Additionally, marine mammal observer databases, along with passive acoustic monitoring data, should be maintained for information on the distribution and behavior of marine mammals. Radiated acoustic energy from airguns should be related to marine mammal observer reports and other marine mammal data.
- Oil and gas industry associations could play a role in facilitating the collaboration between oil and gas operators, contractors, regulators, and scientists so that all parties can jointly exploit currently missed opportunities to share and/or obtain useful, multi-disciplinary information about the potential impacts of the various exploration methods and make the results available.
- Some countries have inherent incentives for airgun surveys within their work programs and in doing so, have implied disincentives for alternative technologies. Governments should discontinue programs that discourage the utilization of non-airgun technologies. Governments should develop incentives for any alternative technologies that are found to have clear environmental benefits over current airgun technology.

- The academic geophysical community should also be encouraged to research quieter alternatives to airguns, with the aid of government and/or industry funding.
- Regulators should encourage and help fund research and development of quieter, alternative sources and their impact assessments.
- Governments and regulators should produce, domestically and internationally, clear, consistent environmental compliance laws, regulations, and standards, as well as apply them in a similarly consistent manner across different geographical areas. This would facilitate the development of more environmentally benign technologies.

Additional Notes/Information

While proponents of LACS and gravity gradiometry, two technologies we mention in our tables, were unable to attend our workshop, we nevertheless supply information about these technologies in the interest of being more complete.

From:

http://www.bjorge.no/modules/module_123/proxy.asp?D=2&C=233&I=1691&mid=-1&sid=-1&pid=766

LACS (patented) Low-frequency Acoustic Source

LACS can be used for seismic acquisition. It is a digital source, is small in size, and does not need high pressure air to operate. It can control the spectral contents of single pulses, is repeatable with precise timing, and has a high pulse rate yet no interaction between pulses. In contrast, the interaction between airgun pulses which are close together in time (gas bubbles) is less predictable and weakens the pulses. Several LACS units may operate together to provide an increased pulse pressure. The system also allows accurate simulation of shipping noise, since it is similar both in the time and frequency domain, without a sweeping fingerprint.

Bjørn Askeland, a developer of LACS, adds: "…The important issue now is to get an overview of the potential of time-coded sequences for marine seismics. LACS is a digital high fire rate marine source. In telecommunications signals used to be analog, but now most of them are digital."

"… new sources [could] replace airguns for borehole seismic applications within 5 years if research money is made available and access to offshore wells is regulated. Taxation of borehole airgun surveys may be a way of speeding up the technological development and also for providing the necessary research money…".

Gravity Gradiometry

The following is supplied by Duncan Bate, ARKeX Inc.:

Unlike air guns, both gravity and gradiometry are passive; no energy is put into the earth or water. Variations in the naturally occurring gravity field are measured. Both technologies are fairly well developed and have been used by both mining and oil and gas industries for decades.
The major difference between gravity and gravity gradiometry is the way the field is measured. To measure the gradient of the field, a much more complex piece of equipment is needed, which is newer and more expensive than traditional gravity meters. The benefit of gravity gradiometry is the increase in resolution. The resolution is now more on the same scale as seismic data. Also, there has been a big step forward in the processing and interpretation of gravity gradient data. Gravity and gravity gradiometry are not applicable in all geological settings, and seismic data will always be preferred. However, in the correct setting, working with an integrated data set of seismic and gravity gradiometry, a better picture of the subsurface can be delivered which may also reduce the amount of seismic needed.

Additional Notes/Information from Participants:

Christopher Clark:

Past research has shown that bowhead and gray whales respond to seismic airgun arrays by moving away from and avoiding the area of the seismic survey (*Malme, C.I., Miles, P.R., Clark, C.W., Tyack, P., and Bird, J.E. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. Phase II: January 1984 migration. Report of Bolt Beranek & Newman, Inc., Cambridge, MA, to U.S. Minerals Management Service, Anchorage, AK. NTIS PB86-218377*.; *Richardson, W.J., Greene, C.R., Jr., Malme, C.I., and Thomson, D.H. 1995. Marine mammals and noise. Academic Press, New York, 576 pp.*). There is also evidence that baleen whales change their vocal behavior in response to seismic exploration sounds. For example, blue whales summering in the Gulf of St. Lawrence increased the rates at which they produced mid-frequency (30-90Hz), social calls when a seismic sparker was operating (*Di Iorio, L., and Clark, C.W. 2009.* doi: *Exposure to seismic survey alters blue whale acoustic communication. Biol. Lett., doi: 10.1098/rsbl.2009.0651, 4 pp.*), while fin whales wintering in the area to the west of the British Isles stop singing in the presence of seismic airgun surveys *(Gagnon and Clark, unpublished data*). Di Iorio and Clark (2009) suggested that the blue whales increased their call rates as a way of compensating for the increased amount of background noise from the sparker. The fin whale response of song cessation is similar to that of humpback whale singers when disturbed by loud sounds or noises. In sum, none of the observed responses by large whales to geophysical exploration sounds is surprising, and we should expect continuing evidence to accumulate demonstrating that these low-frequency specialists respond to seismic impulses and seismic surveys in ways that are biologically sensible.

John Diebold:

A larger number of smaller airguns can be more effective when it comes to focusing the energy downwards, especially at higher frequencies. In theory, increasing receiver density can have a similar effect, and the proprietary "Q" streamers do this in the along-track direction. But with the current approach of individual streamers, it's dangerous to increase the across-track density very much.

With Wide Azimuth acquisition, there are more sources (typically 3 or 4) but the total number of shots is about the same, although they are more greatly distributed in space. If the number of receivers was doubled, the same result could (in principle) be achieved with half the shots. This certainly is what happens with multi-streamer vs. single-streamer 3D acquisition.

There are a couple of things going on simultaneously with tow depth of the array. Deeper towing enhances low frequencies in all directions, but it also limits the useful upper frequency boundary, and thus the resolution in travel time. A secondary effect is that shallow towing decreases the horizontal sound propagation, due to the Lloyd's mirror cancellation effects.

John Young:

Typical offshore 2D seismic surveys can cost in the millions to tens of millions of dollars, 3D seismic can cost in the tens to hundreds of millions, and deep water wells would also be in the tens to hundreds of millions. Field production facilities can be in the hundreds of millions to billions of dollars.

To image the geological target requires a certain degree of signal to noise ratio. This can be obtained by either reducing the noise or increasing the signal or a bit of both. For example, additional receivers can provide both additional signal and/or reduced noise through beam steering. Futhermore, finer receiver spatial sampling allows one to sample the noise better which, in turn, allows it to be removed more easily and optimally when the data are processed.

As an example (not an endorsement), WesternGeco's Q streamer acquisition technology has three distinct components. 1) It has finer receiver sampling in the inline direction or along a given seismic cable; 2) It has the ability to measure each source signature and then extrapolate to a far-field signature; 3) It has both lateral and vertical cable position control. Improvements to the data come from additional inline receiver sampling which allows one to sample the noise for better noise removal and/or sum adjacent receiver channels for increased signal. By measuring each source for each shot of the airgun, one can use individual signatures to deconvolve the data (in other words, remove the source signature on a shot-by-shot basis leaving only a spike for each acoustical interface). This in effect improves the signal-to-noise ratio (S/N). By controlling the positions of receivers more precisely one can minimize smear (most data processing algorithms like straight cables) which again is a form of increased S/N.

Another example (again, not an endorsement) so called across-track or cross-line density has increased to the point that the PGS Ramform Sovereign (2008) provides 22 streamer capability. PGS has since gone a step further with the development of "GeoStreamer" technology which allows streamers to be equipped with both a pressure and velocity phone. The dual sensor capability allows suppression of the surface ghost. Suppression of the surface ghost provides improved data quality via broad bandwidth/higher resolution and lower noise from being able to tow the streamers deeper. The deeper tow also allows one to work in higher sea states which provides greater operating efficiencies i.e., less time footprint in a given geographic area. On the other hand, operating in higher sea states means mitigation through visual detections of marine mammals in the safety zone is less effective.

Peter van der Sman:

Improvements in reducing high frequency noise could be made in airguns by altering the port/throat design. Some work has been done in the past to illustrate this. While the ideas are published, the results are not available in the open literature. However, a patent has been filed on this concept in 2005 proposing such changes and suggesting an attendant reduction in high frequency noise.

Noise can be added in or convoluted with the actual data at all stages of the exploration process, and the actual design and implementation of this whole chain of events (design, acquisition, processing, interpretation, etc.) will decide if the final objective can be met. For instance, self-noise from the streamer can be an important consideration. Increasing the output power at the source may not help, and indeed even hinder, the signal to noise ratio, if the source power is not the weakest link. "Shot-generated noise," for instance, is source energy that cannot be interpreted. If the sound decay of the previous shot has not yet reached ambient levels, increasing the source power may in fact raise the noise level for the subsequent shot. Though difficult, ideally, all components in the exploration process must be matched and designed to work optimally together. The source level should be lowered to the point just before it becomes the weakest link.

Warren Wood:

Deep Towed Acoustic Geophysical Systems (DTAGS) can detect areas missed by surface-towed airguns, but there is less penetration than from surface-towed airguns. This is mostly due to frequency content. DTAGS operates at higher frequencies (220-850 Hz) thus providing greater resolution at a cost of reduced penetration (100-200m in sand, 1000 m in soft mud). The vertical resolution is better because of the higher frequency content, and the horizontal resolution is better because of the proximity to the target (i.e. deep).

Any deep-towed instrument, of which DTAGS is one, limits the speed of the towing vessel. DTAGS is towed at 2.0 to 2.5 knots, whereas a surface towed seismic system may be towed up to 3 times faster, thus covering a greater number of kilometers per day of ship time. For surface or deep-tow, traversing from site to site requires pulling in all the gear and traveling at full speed (15-20 knots) to the next site and re-deploying the source and receivers. Deployment and recovery of DTAGS requires 2-3 hours. This is perhaps slightly more than required for a small surface seismic system, but much less than for a large 3-D system.

With the DTAGS system in its present form, there is also an issue of navigating the source and receivers. Right now, the system is simply towed, with knowledge of its location but without having complete control over where it goes (on the sub-wavelength scale). However, technology exists to solve this problem, so this could be accomplished with adequate funding.

Dave Ridyard:

The EM source is towed deep, 10-50 m above the seabed. As the depth of investigation of the EM method increases in the future, the power of the technology to de-risk further exploration efforts will increase accordingly.

Rune Tenghamn:

The latest version of PGS's Electrical Marine Vibrator will probably have an efficiency which is 4-6 times higher than for an airgun, though this needs to be tested before it can be confirmed. The Marine Vibrator is as reliable as an airgun.

Vibrators could have multi-azimuth applications. With coded output, several vibrators can be used at the same time with a different azimuth.

Vibrators have been used at a water depth of 100 m, but from an operational perspective, it is difficult to operate them at great depth (>1,000 m). They are pressure compensated and can therefore be used at different depths. The limitation is the length of the umbilical (electrical losses) and the change of air density. At some depth, the air will become a liquid or have such a high density that the performance will be affected.

To have mainly vertical propagation, the vibrator has to be at the right depth. For 20 Hz, the source would have to be at 18.75 m (a quarter of a wavelength). This is not possible if one is operating in shallower water. Seafloor reflections will spread the energy more in shallow water.

In shallow water operations with 6-10 sources, one has the option to not only send out a signal once at each location, but to "stack" several signal sweeps or sequences, i.e. repeat the signal generation at the same source location until an adequate signal to noise ratio is achieved. By doing this, one can improve the signal to noise ratio even if the source itself is rather weak. The reason one can "stack" the signal with a marine vibrator (a controlled source) is that the signature of the signal can be made identical each time. For an airgun, the signature will change from shot to shot, which will make this process less effective.

Even if many vibrator sources are needed for deep-water operations, the peak signals will be much quieter than for an airgun array. This is due to three factors: 1) the energy is more spread out in time; 2) the frequency is more spread out in time; 3) only the energy in the seismic band of interest is sent out.

Rob Habiger:

Low Frequency (~1-10 Hz) measurements of the earth's passive seismic wave field are being studied by multiple academic and industry groups as a new technology for identifying and delineating hydrocarbon reservoirs. This technology has been predominately applied on land where acquisition instrumentation, survey design, and processing workflows/software are evolving fairly rapidly among a limited technical community. The technology is much less mature for marine applications, with

only one offshore survey acquired to date. Additional experiments are required to fully test it offshore and advance its application to oil and gas exploration.

Peter Duncan:

Passive seismic (using earthquakes or interferometry) for structural imaging is a lot less costly than the acquisition of conventional seismic on land. However, it may not be in the marine environment (compared to streamer acquisition) as it requires the deployment of ocean bottom receivers, either cables or autonomous nodes.

Passive imaging techniques today offer a lower resolution imaging suitable for frontier exploration and to rank order a list of exploration opportunities to determine which are the most likely to be successful, and therefore pursued, but they are not sufficient for field development.

The frequency limit of 20 Hz achievable with interferometry means that the resolution is low. Conventional streamer data has signal content up to 60 Hz and sometimes higher, thus achieving higher resolution. Over the next years (perhaps 5), passive techniques might be able to achieve higher frequencies, hence higher resolution.

****

Note: The following tables contain values that are highly variable, e.g. from survey to survey, etc. We have attempted to give our best guess in the interest of giving the reader "ballpark" values only. Many thanks to Ron Brinkman, John Diebold, John Hildebrand, and Warren Wood, for filling in values for airguns and other acoustic sources used in seismic surveys.

Table 1. Characteristics of various technologies used to image the ocean substrate for petroleum deposits.

	Pings /Survey	J /Ping	Duty Cycle	Peak Frq	Frq Range	Watts	Peak Pres re 1 µPa	Pulse Duration	Directionality sr/4pi	Source Depth	Tow Rate
Added noise:											
Airgun Array &	100,000	2.5 x 10^5	20 s	50 Hz	5-200 Hz@	8.3 x 10^6	256 dB	.03 s	0.25	3-12 m	4 kts
Silenced Airguns										3-12 m	4 kts
Marine Vibrators	Similar to airguns			10 Hz	6-100 Hz#	?	20-50 dB below airguns	6-10 s	omni	0-1000 m	0-4 kts
DTAGS	c20k		30s	650 Hz	220-850Hz			250ms	omni	0-6 km	2kts
Para-metrics	?	?	?	?	?	?	?	?	10 deg.	0-6 km	?
LISA			100%	10	5-500	20-200K	210@1m	continuous	variable	0-100m	0-4kts
Sparkers +	c20k	300	1 s	500 Hz	480-520 Hz	1.5 x 10^5	233 dB	2 ms	omni	0-6 m	
Boomers	c20k	280		600Hz	0.1-15 kHz			2-3 ms	omni	0-6 m	4 kts
LACS**				50 Hz	10-150 Hz		212 dB	8-100 ms			
No added noise:											
Gravity*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Gravity Gradiometry*	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Passive Seismics	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
EM	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Near seabed	1.5 kts
Micro-seismics	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Receivers:											
Fibre Optics	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

*Added by Duncan Bate, ARKeX Inc., a supplier of gravity gradiometry

**Added by Bjørn Askeland, a developer of LACS

***LACS increases its signal energy by transmitting many pulses at a rapid rate.

Any harmonic attenuated, practically no energy above 100Hz

@ - Frequencies extend to at least 10,000 Hz, but typically, the industry will record at 2 ms intervals, which means that no frequencies > 250 Hz are recorded, regardless of what

& - Turner et al. 2006. Preliminary acoustic level measurements of airgun sources from ConocoPhillips' 2006 seismic survey in Alaskan Chukchi Sea. JASCO Research Ltd. Report, July 27, 2006.

+ - Cannelli, G.B. and D'Ottavi, E. 1994. Optimization of marine sparker source efficiency by electroacoustic method. IEEE I-750-755.

okeanos - Stiftung für das Meer
Auf der Marienhöhe 15
D-64297 Darmstadt

STIFTUNG FÜR DAS MEER
okeanos

Telefon +49- 6151-918 20 23
Telefax +49- 6151-918 20 19
mail@okeanos-stiftung.org
www.okeanos-stiftung.org

Table 1 (cont'd.).

	Days /Survey Area	Water Depth	Burial Depth	Vert. Resol.	Horiz. Res.	Deployment	Receiver Density	Signal Process. Maturity	Est. Time to Commer. Avail.	EIA Maturity	Max. fire rate
Added noise:											
Airgun Array &	30	all		30 m	20-200	surface tow	variable	mature	available	medium	10 s
Silenced Airguns		all		30 m	20-200	surface tow	variable	mature	1 yr	medium	10 s
Marine Vibrators		all		3 m	20-200	8 - 15m	variable	medium	3-5 yrs	young	continuous
DTAGS		all	1km	1.5	20m	Deep tow (full ocean)	variable	medium	1 yr	young	30 s
Para-metrics	?	all	?	?	?		variable	young	5-10 yrs	infant	10 pings/s
LISA		all		30 m	30m	surface tow	variable	young	5-10 yrs	young	
Sparkers +		<1000		1 m	20-200	surface tow	variable	mature	available	young	5 s?
Boomers	1-14 days	<1000		1.5 m	20-200	surface tow	variable	mature	available	young	5 s?
LACS**								medium	2 yrs.	available	15 shots/s***
No added noise:											
Gravity*	~200 sq mi/mo.	all	all	depth dep.	2000m	boat/air/water bottom	N/A	mature	available		
Gravity Gradiometry*	~200 sq mi/mo.	all	all	depth dep.	200m	boat/air	N/A	medium	available		
Passive Seismics	365	all	water bottom	300m	150m	water bottom	4/sq mi	mature	5 yrs	young	N/A
EM	5-100	>20 m	<6 km	1-200 m	1-200 m	seabed	500-5,000m	medium	available	emerging	
Micro-seismics	life of field	all	water bottom	100m	50m	water bottom	4/sq mi	medium	2 yrs	young	
Receivers:											
Fibre Optics	life of field	all	water bottom	100 m	50 m	seabed	150/sq m	mature	available	emerging	

*Added by Duncan Bate, ARKeX Inc., a supplier of gravity gradiometry

**Added by Bjørn Askeland, a developer of LACS

***LACS increases its signal energy by transmitting many pulses at a rapid rate.

Any harmonic attenuated, practically no energy above 100Hz

@ - Frequencies extend to at least 10,000 Hz, but typically, the industry will record at 2 ms intervals, which means that no frequencies > 250 Hz are recorded,

& - Turner et al. 2006. Preliminary acoustic level measurements of airgun sources from ConocoPhillips' 2006 seismic survey in Alaskan Chukchi Sea. JASCO Research Ltd. Report, July 27, 2006.

+ - Cannelli, G.B. and D'Ottavi, E. 1994. Optimization of marine sparker source efficiency by electroacoustic method. IEEE I-750-755.

okeanos - Stiftung für das Meer
Auf der Marienhöhe 15
D-64297 Darmstadt

STIFTUNG FÜR DAS MEER
okeanos

Telefon +49- 6151-918 20 23
Telefax +49- 6151-918 20 19
mail@okeanos-stiftung.org
www.okeanos-stiftung.org

Table 2. Applications of various technologies used to image the ocean substrate for petroleum deposits.

	Applications								Penetration	
Added noise:	**Site Survey**	**2D**	**3D**	**4D**	**Refraction**	**High Res**	**WAZ**	**Other**	**Shallow**	**Deep**
Airguns	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Silenced Airguns	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Marine Vibrators	P	P	P	P	P	Y	P	P	Y	Y
DTAGS	Y	P	P	P	P	Y	P	P	Y	N
Para-metrics	N	N	N	N	N	P	N	N	P	N
LISA	P	P	P	P	P	Y	P	P	Y	Y
Sparkers	Y	N	N	N	N	Y	N	N	Y	N
Boomers	Y	N	N	N	N	Y	N	N	Y	N
LACS	P	P	P	P	P	P	P	P	P	P
LACS**	Y	Y	Y	Y	P	P	P	P	Y	P
No added noise:										
Gravity	-	+	+	+	+	-	+		-	+
Gravity*	-	++	++	-	N/A	-	N/A		+	++
Gravity Gradiometry*	+	++	++	+	N/A	+	N/A		++	++
LF Passive Seismics	-	+	+	+	+	-	+		+	+
CSEM / 3D EM	+	++	++	++	+	+	+		++	+
Magneto	-	+	+	+	+	-	+		-	+
Heatflow	-	+	+	+	+	?	-		-	+
Micro-seismics	-	+	+	++	-	-	+		-	+
PSTT	-	+	+	+	+	-	+		-	+
Daylight Seismic	-	+	+	+	-	-	+		-	+
Receivers:										
Fibre Optics	+	+	+	++	+	+	+		+	+

"P" = possibly

*Added by Duncan Bate, ARKeX Inc., a supplier of gravity gradiometry

**Added by Bjørn Askeland, a developer of LACS

Table 3. Characteristics of various types of seismic surveys and imaging technologies.

Uses	Area Covered (typically)	Survey Time	Sound Intensity (dB re 1µpa)**	Power (Watts)*	Incidence (Shots / Day)	Peak Pressure (PSI)	Frequencies (Hz)
Shallow							
2D	100-5,000 miles	28 days-6 mos.	215-230 dB	150 - 270 KW	4,320 - 8,640	2,000	10-10,000 #
3D	9-1,000 sq. miles	2 mos.-1 year	240-255 dB	150 KW	4,320 - 8,640	2,000	10-10,000 #
4D	9 sq. miles	2 weeks-1 mo.	240-255 dB	150 KW	4,320 - 8,640	2,000	10-10,000 #
Deep							
Site Spec. Survey	60-600 miles	5 days-2 mos.	200-230 dB	1,500	17,280	2,000	10-10,000 #
2D	100-10,000 miles	28 days-1 year	215-230 dB	150-270 KW	4,320 - 8,640	2,000	10-10,000 #
3D (including WAZ)	9-25,000 sq. miles	2 mos.-3 years	240-255 dB	150 KW	4,320 - 8,640	2,000	10-10,000 #
4D	9-27 sq. miles	2 weeks-1 mo.	240-255 dB	150 KW	4,320 - 8,640	2,000	10-10,000 #
Shallow and Deep							
Refraction	Linear	1 day		270 KW	1,440	2,000	6 - 60
Bathymetry (@)	60-120 miles	varies	210 dB	100 - 2,000 KW	8,640 - 86,400	N/A	3,500 - 12,000
High Res		varies		500 KW	17,280	2,000	30 - 300
Sidescan Sonar	9-90 sq. miles	5 days- 2 weeks			1,440 - 7,200	N/A	50-600 kHz
Site Spec.Survey	60-120 miles	5 days- 2 weeks	200-230 dB	1,500 KW	17,280	2,000	10-10,000 #
Sub-Bottom Profile	60-120 miles	5 days- 2 weeks	200-230 dB		1,440 - 7,200	N/A	10-10,000 #
VSP	near well	1-2 days	200-230 dB		4,320 - 8,640	2,000	10-10,000 #

Note: several instruments are often used concurrently, such as bathymetry and high res for site surveys

* - note: actual units are total energy, Joule/square meter-Hz; one Joule = one Watt-second

** - note: an airgun signal is an energy signal (not power), therefore intensity @ 1 µPa makes more sense

- typically, the industry will record at 2 ms intervals, which means that no frequencies > 250 Hz are recorded, regardless of what is generated.

@ - time, area, and power values vary a lot for swath bathymetry surveys.

In deep water, power is high, pings are further spaced apart, swaths are wide, so more area is covered in a given time.

In shallow water, power is low, pings are frequent, swaths are narrow.

Participants

1. Participants (Chair, then in alphabetical order) and their specialty

Chair: Leila Hatch, Ph.D., NOAA, Scituate, Mass., USA; marine mammals, marine ecologist

Ronald Brinkman, Senior Staff Geophysicist, Minerals Management Service, New Orleans, LA, USA; regulations and R&D

Christopher W. Clark, Ph.D., Director Bioacoustics Research Program, Cornell Laboratory of Ornithology, Ithaca, NY, USA; marine mammals, bioacoustics

John Diebold, Ph.D., Chief Scientist for Marine Operations, Lamont-Doherty Earth Observatory, Columbia University, Palisades, NY, USA; seismic surveys for science

Peter Duncan, Ph.D., President, Microseismic, Inc., Houston, TX, USA; passive seismic tomography

Rob Habiger, Ph.D., CTO, Spectraseis AG, Zürich, Switzerland; passive seismic

John Hildebrand, Ph.D., Professor of Oceanography, Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, USA; marine mammals, bioacoustics, seismic surveys for science

Phil Nash, CTO, Stingray Geophysical Limited, Guildford, UK; fiber optic sensors

Jeremy Nedwell, Ph.D., Founder, Subacoustech Ltd., Southhampton, UK; low frequency projector arrays and airgun “silencers”

Dave Ridyard, President, EMGS, Houston, TX, USA; electromagnetic survey techniques

Rune Tenghamn, Vice President, Innovation and Business Development, PGS Data Processing and Technology, Houston, TX, USA; marine vibrator technology

Peter van der Sman, Shell, Amsterdam, Netherlands; airguns

Lindy Weilgart, Ph.D., Department of Biology, Dalhousie University, Halifax, NS, Canada; marine mammals, bioacoustics

Warren Wood, Ph.D., Naval Research Laboratory, Stennis Space Center, MS, USA; deep water seismic source

John Young, Marine Sound Issue, Mgmt. Team Coordinator, ExxonMobil Exploration Co., Houston, TX, USA; petroleum industry use of seismic data

Presentation Abstracts

An Overview of the Uses of Sound by Marine Mammals and the Impacts from Anthropogenic Underwater Noise Sources

Lindy Weilgart, Dalhousie University

Marine mammals, particularly cetaceans (dolphins, porpoises, and whales), use sound for all aspects of their life, including reproduction, feeding, communication, navigation, hazard avoidance, and otherwise sensing their environment. Hearing is their primary sense, as sound travels very efficiently underwater (hundreds of kilometers), whereas vision is limited to only tens of meters. Some cetacean species are primarily solitary and widely scattered, so that sound could be particularly important in uniting them. In blue and fin whales, for instance, females probably must rely on finding mates by the loud, low frequency sounds males make. Such calls can theoretically travel almost across ocean basins, at least in the absence of appreciable human-made noise. Cetacean vocalizations are thought to be used for purposes such as to coordinate movements and maintain contact between group members, to repel mating competitors and attract mates, to identify group membership, etc. Mating songs probably also allow females to assess the quality of potential mates. Echoes from the ice may help whales found in polar waters navigate through open leads safely (Ellison et al. 1987). Similarly, whales likely use acoustic cues, such as echoes from ocean bottom features or surf noise, to find their way during long migrations.

Some of the observed effects of anthropogenic underwater noise on marine mammals include: changes in vocalizations (increases in call duration, falling silent, etc.), displacement or avoidance, changes in diving or feeding behavior, changes in swim speed or breathing rate, shifts in migration path, stress, hearing damage (from captive animal studies), and strandings and deaths at sea. Specifically, some of the more concerning impacts from noise are: noise causing hemorrhaging and death in beaked whales (Jepson et al. 2003, Fernández et al. 2005), the displacement of gray whales from their breeding lagoons for about 10 yrs. (Bryant et al. 1984), the avoidance of noise by killer whales for 6 yrs. (Morton and Symonds 2002), belugas fleeing from noise at distances of 35-50 km and staying away for 1-2 days (Finley et al. 1990, Cosens and Dueck 1993), increased stress hormones in a captive beluga whale with exposure to noise (Romano et al. 2004), indications of a reduction in feeding in sperm whales (Miller et al. 2009), and a greater fatal entanglement rate in fishing gear by humpbacks exposed to noise (Todd et al. 1996). Given that we know cetaceans use sound for so many life functions, the consequences of noise might be to decrease their feeding efficiency, place higher energetic demands on them, interfere with their group cohesion and social behavior, cause mother-calf separations, increase predation pressure, produce more navigational errors (e.g. strandings, entanglements in fishing gear, etc.), and lower calving rates. Thus, the welfare of cetacean populations could be impacted. Indeed, noise is thought to contribute to some species' population declines or their lack of recovery (e.g. killer whales, western gray whales; NMFS 2002, IWC 2007).

References

Bryant, P.J., Lafferty, C.M., and Lafferty, S.K. 1984. Reoccupation of Guerrero Negro, Baja California, Mexico, by gray whales. *In* The gray whale, *Eschrichtius robustus*. *Edited by* M.L. Jones, S.L. Swartz, and S. Leatherwood. Academic Press, Orlando, Florida. pp. 375-87.

Cosens, S.E., and Dueck, L.P. 1993. Ice breaker noise in Lancaster Sound, NWT, Canada: implications for marine mammal behavior. Mar. Mamm. Sci. **9**(3): 285-300.

Ellison, W.T., Clark, C.W., and Bishop, G.C. 1987. Potential use of surface reverberation by bowhead whales, *Balaena mysticetus*, in under-ice navigation: preliminary considerations. Rep. Int. Whaling Comm. No. **37**: 329-332.

Fernández, A., Edwards, J.F., Rodríguez, F., Espinosa de los Monteros, A., Herráez, P., Castro, P., Jaber, J.R., Martín, V., and Arbelo, M. 2005. 'Gas and fat embolic syndrome' involving a mass stranding of beaked whales (family *Ziphiidae*) exposed to anthropogenic sonar signals. Vet. Pathol. **42**: 446-57.

Finley, K.J., Miller, G.W., Davis, R.A., and Greene, C.R. 1990. Reactions of belugas, *Delphinapterus leucas,* and narwhals, *Monodon monoceros*, to ice-breaking ships in the Canadian high arctic. Can. Bull. Fish. Aquat. Sci. **224**: 97-117.

IWC (International Whaling Commission). 2007. Report of the Scientific Committee. Annex K. Report of the Standing Working Group on Environmental Concerns. J. Cetacean Res. Manage. (Suppl) **9**: 227-296.

Jepson, P.D., Arbelo, M., Deaville, R., Patterson, I.A.P., Castro, P., Baker, J.R., Degollada, E., Ross, H.M., Herraez, P., Pocknell, A.M., Rodriguez, F., Howie, F.E., Espinosa, A., Reid, R.J., Jaber, J.R., Martin, V., Cunningham, A.A., and Fernandez, A. 2003. Gas-bubble lesions in stranded cetaceans. Nature (London), **425**: 575-576.

Miller, P.J.O., Johnson, M.P, Madsen, P.T., Biassoni, N.,Quero, M., and Tyack, P.L. 2009. Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. Deep-Sea Research I **56**: 1168–1181.

Morton, A.B., and Symonds, H.K. 2002. Displacement of *Orcinus orca* (L.) by high amplitude sound in British Columbia. ICES J. Mar. Sci. **59**: 71-80.

NMFS (National Marine Fisheries Service). 2002. Status review under the Endangered Species Act: Southern Resident Killer Whales (*Orcinus orca*). NOAA (National Oceanographic and Atmospheric Administration) Tech. Memo. NMFSNWAFSC-54, NMFS, Seattle, Washington. 131 pp.

Romano, T.A., Keogh, M.J., Kelly, C., Feng, P., Berk, L., Schlundt, C.E., Carder, D.A., and Finneran, J.J. 2004. Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. Can. J. Fish. Aquat. Sci. **61**: 1124-1134.

Todd, S., Stevick, P., Lien, J., Marques, F., and Ketten, D. 1996. Behavioural effects to underwater explosions in humpback whales (*Megaptera novaeangliae*). Can. J. Zool. **74**: 1661-1672.

Biological Implications of Chronic Exposure from over Large Spatial Scales: Seismic Surveys

Christopher W. Clark, Cornell University

There is little to no precedent as to the scientific processes for quantifying and evaluating the potential impacts of chronic exposure from anthropogenic sources of sound on marine animals. This statement certainly applies to the situation when a seismic airgun array is the sound source, and to a lesser extent when another mechanism is the source of the intense, impulsive survey signal (e.g., sparkers). Although shipping noise is undoubtedly the largest contributor to chronic ocean noise on an ocean basin scale, noise from a seismic airgun array survey can change the acoustic environment on a seasonal timescale and for a region much larger than the region within which the survey is conducted. It is noteworthy that a seismic survey generates sound intentionally, while a ship produces noise as a bi-product of its propulsion system. Thus, although one could say that the seismic sound is a signal and the ship sound is noise, from the perspective of a marine mammal both activities introduce sounds that have the potential to interfere with and mask bioacoustically important activities (e.g., communication, finding food, navigating, detecting predators). Under sound propagation conditions which promote frequency and time dispersion, a seismic signal can be transformed from an impulsive, reasonably broadband sound into a much longer sound with biologically salient features. Under such circumstances the original, *ca*. 100ms seismic signal can last for many seconds and/or have distinctive frequency-modulation characteristics such that the original seismic sound is no longer impulsive and simply noise, but acquires structure and becomes bioacoustical clutter. Present regulations do not yet

recognize this acoustic phenomenon as representing a shift from the impulsive into the non-impulsive behavioural response regulatory paradigm. Overall, these seismic survey situations can result in complex acoustic scenes that infuse large ocean areas with varied mixtures of impulsive noise and frequency-modulated sounds, often convolved with high levels of reverberation. As a result, for situations in which multiple seismic sources are operating concurrently in the same region, the active bioacoustic space for a given species can be dominated by seismic sounds for periods of many months.

Impacts of Airguns on Marine Animals: Thresholds for Injury and Behavioral Alterations

John Hildebrand, Scripps Institution of Oceanography

The sound pressure fields created by airguns have been shown to create both injuries and behavioral disturbances to marine animals such as cetaceans and fish. This presentation provides background information on relevant acoustic metrics, and examples of injuries and behavioral disturbances following exposure to operating airguns.

Decibel sound pressure level (dB re: μPa RMS) is the standard metric for describing an acoustic field, but may not be the best criterion for judging the impact of sound exposure. Acoustic peak pressure (dB re: μPa peak) and sound exposure level (dB re: μPa – s) are alternate metrics with appeal for impulsive sources such as airguns. Using acoustic peak pressure accounts for the potential for sound impact, independent of duration. Alternately, sound exposure level is a metric that takes into account the signal duration by integration of the sound pressure level over the duration of the signal, a proxy for acoustic energy. A dual exposure criteria for tissue injury and behavioral disturbance from noise exposure has been proposed, based on these two metrics.

Studies with captive beluga whales and bottlenose dolphins have demonstrated that following exposure to sounds of sufficient intensity, these animals exhibit an increased hearing threshold, described as a temporary threshold shift (TTS). The trade-off between sound intensity and duration that produces TTS, follows roughly an equal-energy curve; long duration signals produced TTS at lower signal intensities than short duration signals.

Field studies have demonstrated behavioral disturbance of cetaceans following exposure to airguns. Migrating gray whales deviate from their swim tracks to reduce received sound pressure levels from exposure to airguns. Likewise, observations during seismic surveys demonstrate that small odontocetes show large lateral spatial avoidance, while mysticetes and killer whales show localized spatial avoidance.

Studies with caged fish suggest that the ears of fish exposed to airguns sustain severe damage to their sensory cells, with no evidence of repair or replacement of damaged cells after exposure. Likewise, acoustic mapping and fishing trawls before, during, and after airgun usage suggest severely affected fish distribution, local abundance, and catch rates.

Marine seismic surveys for science: Purpose, operation and product

John Diebold, Lamont-Doherty Earth Observatory

Marine seismology using controlled sources began in the 1930's, producing fundamental new understanding of the extension of continental structures along continental shelves, and also that the deep ocean is floored by an entirely different kind of crust. By necessity, the sources used were explosives, sometimes in great quantity (many hundreds of pounds.)

The introduction of the airgun as a marine seismic source during the early 1960's represented a great increase in safety and resolution, though it took several decades of additional development to achieve the kinds of airgun arrays that are in use today. These arrays typically use a dozen or more small airguns, firing simultaneously, but spread out in space so as to deliver a short and repeatable pulse of acoustic energy in a generally downward direction.

Current developments in active-source marine seismology are increasing the resolution with which acoustic images can be made, and increasing the depths that can be imaged. Typically the latter effort requires longer arrays of passive receivers, though signal strength is a concern as well. Increased resolution typically requires smaller, specially designed sources and increased number and wider aerial disposition of receivers.

The resulting images and structural details are a critical data type, providing fundamental improvements in humankind's understanding of earth processes. This understanding in turn allows important progress to be made in a wide range of topics from the locations and mechanics of earthquakes to the history of climate change.

Airguns, explosives, and a number of other marine seismic sources depend upon the same basic principle – a bubble of gas, which, due to its internal pressure, expands. In the case of airguns, the pressure within the initial bubble is well constrained, and is far less than that produced by the rapid combustion of explosive solids. As a result the expansion of the air bubble is much slower, and comparatively few high frequencies are produced.

On board US academic research vessels environmental impact is reduced in a number of ways. Minimum source level is used in the first place, and timing of each survey is planned to avoid times of known seasonal breeding, feeding and migration for key marine mammal species. Track lines are often adjusted for local areas of sensitivity and principal investigators are encouraged to favor deeper water options whenever possible. A comprehensive program of visual observation is always carried out, most often supplemented with passive acoustic monitoring. Typically five experts, independent of other operations, are devoted to these tasks. A complete report of sighting and behavioral descriptions is filed with NMFS for every survey and these data are available for inclusion in larger database efforts.

How Seismic Data Is Used By the Petroleum Industry

John Young, ExxonMobil

By 2030, it is widely estimated that global energy demand will increase approximately 30% from today's level. In order to address this need for energy, the petroleum industry explores for

hydrocarbon deposits beneath the earth's surface including under oceans. Seismic surveys are the most accurate and efficient method currently available for hydrocarbon exploration.

Today, the most common marine seismic operations include acoustic sources and receiver streamers, towed behind a vessel. The sources are activated, releasing sound energy directed downward through the water column and into the earth. As a result of differences in acoustic impedance between geologic strata, seismic energy is reflected back to the streamers. The reflected energy is digitally recorded and processed to obtain a detailed image of the subsurface.

Sophisticated subsurface imaging, facilitated by increased computing power, allows for the identification of previously unknown hydrocarbon deposits and reduces the risks associated with drilling in water depths of up to two miles. Increased drilling success rates equate to increased hydrocarbon reserves for the world's energy needs.

The potential for reducing unnecessary horizontal and high frequency components of sound produced by airguns

Peter van der Sman, Shell

Since the early sixties, the seismic industry started to move away from using dynamite as seismic energy source. The main reason for this move was safety, yet in the years to follow also the environmental impact started being used as a motivation. Being used to deal with impulsive sources, the first alternative the industry came up with was impulsive in nature; the airgun. Yet, it was soon follow with marine vibroseis in the mid sixties. Since then, a host of different sources have been proposed and used. Currently though, over 95 percent of the seismic operations is conducted using airguns. So what are the underlying reasons for the airgun to 'survive' in a Darwinian like sense?

As with any new technology, it takes time to develop it in all relevant aspects needed to realize the desired objectives. A typical timeframe in this sense is often in the range of 10 to 25 years. On the other side, one needs to realize that development is costly and that over the duration of such a development the industry tends to alternate several times through periods of prosperity where new technologies are nurtured and others where technologies are shelved or worse.

In the case of the airgun for instance, it took about 10 years before arrays of airguns emerged, tuning a range of volumes to collectively emit a signal suitable for seismic prospecting. Yet it took another 10 to 15 years or so to develop them into the high-fidelity source systems the industry needs. Marine vibroseis though did not do as well. In contrast to their onshore cousins, the marine version never really got of the ground. The fundamental reason for this may be the geophysical requirement to generate sufficient low-frequent energy (say 5 to 10 Hz) at typical surveying speeds. To do so, units become large and heavy which also prevents the use of fair sized arrays to circumvent this. Then again, the vibroseis technology offers a huge potential in that it can shape both the emitted signal and its frequency spectrum and this is exactly where the technology is believed to have merits in an environmental sense. So is marine vibroseis the way to go or can we still work the airgun system to accommodate both geophysical and environmental constraints.

In my presentation I will present a few concepts and ideas on airguns, aiming to complement the contributions by the other speakers such that we collectively present the whole spectrum and merits of all the technologies at our disposal in the context of the workshop.

A Deep Water Resonator Seismic Source

Warren T. Wood, U.S. Naval Research Laboratory

The Naval Research Laboratory's deep-towed acoustics/geophysics system (DTAGS), originally designed to characterize abyssal plain sediments, is an example of a seismic source technology capable of generating 220 Hz – 1 kHz swept frequency sound waves at levels up to 200 dB (re 1 Pa @ 1 m), and at full ocean depths. The source is composed of a series of five concentric rings each composed of pie-shaped piezo-ceramic material. The natural resonance of the ceramic transducers provides the high frequencies and the size and shape of the barrel-shaped resonator cavity boosts the low frequencies. This combination yields a broadband (over two octaves) signal with a relatively flat spectrum. The solid-state nature of the construction ensures not only that the source is extremely repeatable, but also that it is insensitive to changes in depth; yielding nearly identical signals from the sea surface to full ocean depth (6000 m). The source can be energized with almost any kind of waveform, and at almost any sound level below 200 dB, allowing significant flexibility to tune the source amplitude, frequency, and waveform for specific needs.

Although the resonator source operates in all water depths, it is most useful where other sources fail. As hydrocarbon exploration moves into deeper waters, the signal loss from surface towed sources becomes excessive. In 2000 m (6562 ft) of water signal loss from spherical spreading results in sound levels at the seafloor only 0.05 percent as strong as at the sea surface, (a 66 dB loss in amplitude). For example: a 180 dB source at the surface fades to 114 dB at the seafloor.

DTAGS is currently configured as a towed multi-channel system, capable of recording 48 hydrophones (3 m spacing) for trace lengths of two seconds, at a two kHz sample rate, on a duty cycle of 30 seconds. The system is typically towed at 2 knots at an altitude of 100m above the seafloor. After some conventional, and some unique processing steps, the resulting seismic sections allow detection of both vertical and lateral changes in the sediment as small as 1-2 meters, and can fully resolve features at a scale of 5-10 meters.

To augment its use as a deep-towed multi-channel seismic system, efforts are currently underway to design and build a coupling system to enable the resonator source to be set directly on the seafloor. In this mode we anticipate not only increased excitation of P and S waves, but also increased signal to noise by repeated firings at the same location (similar to techniques used on land with swept frequency systems).

Deep water sources in general, and the DTAGS Helmholz resonator specifically represent an attractive option for achieving commercially useful sound pressure equivalent levels in the earth, while minimizing the instantaneous sound levels in the ocean, particularly the shallow ocean where sound sensitive marine life is concentrated. These advantages are achieved mainly through proximity of the source to the target of interest, and time integration over a highly controlled and repeatable source waveform.

Potential application of 3D EM methods to reduce effects of seismic exploration on marine life

Dave Ridyard, EMGS Americas

Introduction

This paper addresses the question "Can 3D EM methods reduce the amount of seismic activity ?". It does not address the broader question "Is there any need to reduce the amount of seismic activity ?".

3D EM method summary

It has been known for over 80 years that hydrocarbon saturated rocks exhibit higher electrical resistance than brine saturated rocks. In recent years the 3D EM method (Controlled source electromagnetics) has emerged as a powerful exploration tool. A dipole electric source towed close to the seabed generates electric and magnetic fields which are perturbed by any subsurface resistive structures. These fields can be measured by sensors deployed on the seabed. The measurements can be processed to create a 3D image of the subsurface resistive structures. Where a resistor is observed co-located with a prospective hydrocarbon bearing structure, the risk of drilling a dry hole is significantly reduced.

It should be noted that a 3D EM image shows resistors … not hydrocarbon reservoirs. There are many other resistors buried in the subsurface – salt, volcanic rocks, carbonates and methane hydrates all exhibit resistive properties. The deep penetration and high resolution of seismic data is invaluable in creating meaningful, detailed regional geologic models and identifying potential hydrocarbon traps. However, seismic data is clearly more reliable if it is used in conjunction with EM.

Environmental impact of EM

Receivers deployed on the seabed use biodegradable anchors and have negligible environmental impact. The source uses extremely low spatial and temporal frequencies – typically wavelengths of many kilometers and frequencies of 0.1 to 1 Hz. When these low frequencies are considered in combination with the exponential decay of energy caused by highly conductive seawater, the region of potential influence on marine life resulting from EM transmissions is tiny. Furthermore, since EM methods reduce the number of dry wells drilled, the method can be considered environmentally positive.

Potential reduction in seismic activity

In theory, broader application of EM methods could reduce "dry 3D seismic surveys" in the same way it currently reduce dry wells. However, the current impact of EM methods on seismic activity is negligible. There are 2 reasons for this.

1) Current EM methods have neither the resolution nor the penetration to replace seismic in a significant range of exploration and production applications.

2) Even where EM technology is effective, it is underutilized by many oil companies due to the wide spread lack of understanding and adoption of the technology.

Summary and Recommendations

EM offers some, limited potential to reduce the growth in seismic activity, but action is needed in 2 areas to enable this.

1) Further R&D investment is required to grow the application window for EM methods by increasing depth of penetration and resolution of the method.

2) Regulatory changes in leasing practices, taxation, accounting (reserves estimation etc.) can accelerate the adoption of EM methods.

Vibroseis Technology

Rune Tenghamn, PGS Data Processing and Technology

For several decades, airgun sources have dominated the marine seismic acquisition market. Surprisingly, few new source concepts have been presented to the industry during this period. During the eighties, however, developments related to marine vibrator sources took place. These sources were tested mainly for deep target marine seismic applications. These applications have since been limited, due to factors such as high cost, handling and operational difficulties, etc.

During the late nineties, PGS started the development of a completely new electro-mechanical marine vibroseis concept. The objective of the project was to develop a 100% repeatable low-cost vibrator source with an energy output in the frequency band of 6-100 Hz and with a size and weight easy to operate in the field. Target applications of the source are shallow water acquisition, seismic monitoring and environmentally sensitive areas.

A marine vibrator will provide several environmental advantages. Vibrator technology spreads the net source energy over a long period, reducing the acoustic power in comparison to impulsive sources. The peak power of a Marine Vibrator is about 30 dB lower in sweep mode than the corresponding peak power of an impulsive source. This is attractive for applications where high peak power may be problematic. There is no need for heavy equipment and hydraulic systems that can cause hydraulic oil spills. As the electrical vibrator requires only an electrical power supply it can be easily transported to different vessels and locations without any costly installations and potential environmental hazards.

Electrical marine vibrators also have several operational advantages. Due to the high efficiency of the sources, controllable and arbitrary signals can be generated in the frequency band of interest. This fact has been used to develop a control system that makes the acoustic sources repeatable over time. Having a feedback loop for control of the output means that not only can high repeatability be achieved, but the harmonics can also be attenuated. Any mechanical system will generate harmonics. Tests have shown some dramatic change in harmonics generated by a sweep. Some of the harmonics are attenuated by more than 30 dB.

The controllability of the source makes it possible to introduce Pseudo Noise sequences (PN). With the use of PN signals it will be possible to reduce the peak power even more. The PN sequences will not only spread the source energy over time, but will also spread the frequencies over time. This technology will further reduce the peak power for any frequency at any particular time by another 20 dB compared to a sweep.

In a future scenario, we could have an array of controllable marine vibrators with the energy concentrated in the vertical plane through beam steering of the acoustic output. The PN signals would "mimic" natural background noise. By having a continuous "noise" signal the active array would be difficult to distinguish from the natural background noise.

Low frequency passive seismic for oil and gas exploration and development: a new technology utilizing ambient seismic energy sources

Robert M. Habiger, Spectraseis

Introduction

A growing number of low frequency surveys at different oil and gas field locations throughout the world have indicated the possible relationship between certain microtremors and the presence of hydrocarbons. These narrow-band, low frequency (from ~1Hz to ~10Hz) micro-tremor signals offer new types of seismic attributes for the optimization of decisions for exploration and development phases of hydrocarbon exploitation.

Although the primary application of this technology to date has been on land, the potential exists for applying in a marine environment and a proof of concept survey was conducted in April, 2007 in the North Sea.

Data Acquisition

The low frequency data were acquired by using broadband seismometers located on the ocean bottom. The ocean bottom sensors (OBS) can be deployed in deep water and left to record data for days, weeks, or even months. No active sources, such as air guns, are needed in these measurements since only modifications to the earth's natural background energy are monitored. The OBS units can be easily deployed and recovered using well known operating procedures.

Data Processing

The main challenges of moving this technology from land to marine applications are adequate coupling of the sensors to the ocean floor for short data acquisition durations and the large amounts of extraneous ambient noise in the oceans. The nature of the ocean noises and how it can interfere with the quality of measurements and analysis will be discussed along with suggestions for mitigation.

The workflow consists of removing unwanted noise, characterizing the measured signal according to time stability and frequency characteristics, and then calculating low frequency attributes related to hydrocarbon micro tremors.

Conclusions

Low Frequency passive seismic is a new technology that has been applied mostly in land surveys but warrants further investigation and development for application to a marine environment. An initial test has been completed in the North Sea for oil and gas applications and the information gained can be used for planning follow-on surveys to further advance this technology.

Passive Seismic Tomography: structural imaging using natural sources

Peter M. Duncan, MicroSeismic

Reflection seismology is a mainstay of the exploration for hydrocarbons, whether onshore or offshore. While the use of controlled sources (dynamite, airguns or vibrators) for such imaging is certainly the standard, it has been appreciated for many decades that one can also use the earth's natural seismic sources to illuminate the earth's structure. Much of our knowledge of the interior structure of the earth on a global scale has been derived from imaging involving the transmission and reflection of seismic waves whose source was an earthquake on the other side of the earth. Recent work using surface waves excited by the pounding of waves on the beach has begun to unravel the crustal structure of continents. In the last decade there has been work directed at using these same energy sources to create images useful for hydrocarbon exploration and production. These efforts are driven by both environmental concerns and by the expense of conventional seismic imaging. Collectively we refer to these imaging techniques using naturally occurring or ambient noise sources as passive seismic tomography.

The most straightforward application of this passive technology is commonly referred to as passive seismic transmission tomography (PSTT). PSTT creates 3-D images using the observed travel time of seismic signals originating from micro-earthquakes occurring below the target. A sparse array of independent seismometers is established above the target. The array usually consists of 20 to 100 stations each recording the output of a 3-component geophone. With the array in place, the survey proceeds by simply listening. Assuming an initial velocity model, the observed micro-earthquakes are located in time and space using long-standing location algorithms based upon picks of the p and s phase arrival times at each observation station. Once a number of events has been located one flips the process, assumes the origin time and hypocenters of the events are known, and uses some form of travel time inversion to estimate a new velocity model. As more events are added to the dataset, finer estimates of the velocity structure can be achieved. The process proceeds in this boot-strapping fashion until the desired resolution is reached.

If one cross correlates the time signal recorded by the stations of the array established for PSTT, it is often possible to identify 2 other types of seismic signal that are useful for imaging. The first is the surface waves that course back and forth along the earth's surface. The speed of travel of these waves is controlled by the velocity of the material that the wave "sees". Longer wavelengths penetrate more deeply into the earth and therefore sample the earth to a greater depth. This allows one to create a structural image from the rate that these surface waves traverse the array.

The second signal that may be extracted by the cross correlation process contains the multiple reflections of the ambient noise that have been bounced downward from the free surface of the earth and then reflected off velocity contrasts in the subsurface. This technique of recovering 3-D reflection image data from ambient noise signals was first postulated 40 years ago as "daylight seismic". Recent experimental work has shown promise that such a technique may be able to deliver seismic images with a resolution sufficient to be useful in hydrocarbon exploration.

The dBht Method for Evaluating Impact, Airgun Silencers and LF Projector Arrays

J Nedwell, Subacoustech

Introduction

High levels of man-made noise may be created by oil and gas exploration, construction, blasting, and many other offshore activities. Death and injury are extreme effects of underwater sound, occurring mainly where explosives are used. These are relatively well understood and unlikely in a well-managed programme.

However, the more subtle behavioural effects of sound have been an increasing focus of concern internationally. It has been alleged that seismic exploration may have undesirable side-effects upon aquatic animals over ranges of kilometres, or even tens of kilometres.

This paper reports on tests of two possible methods of attenuating the effects of seismic surveying, such that its likely impact on marine mammals will be reduced but its effectiveness as a sound source for seismic surveys would be adequate.

Estimating effects

The ability to estimate effect is critical in rating or comparing technologies intended to reduce the effects of seismic surveying. A simple measurement of sound, such as its peak pressure, is inadequate to judge the likelihood of, for instance, a behavioural avoidance response. Marine species have a wide range of hearing ability, and the same underwater sound will affect each species in a different manner depending upon the its hearing sensitivity and frequency range. Consequently, many researchers are now advocating the use of audiogram-based weighting scales to determine the level of the sound in comparison with the auditory response of the aquatic or marine animal. Madsen *et al.* (2006), for example, recommend that "*as the impact of sounds impinging on the auditory system is frequency-dependent, noise levels should (as for humans) ideally be weighted with the frequency response of the auditory system of the animal in question*".

The dB_{ht} metric developed by the author incorporates the concept of "loudness" for a species. It incorporates hearing ability by referencing the sound to the species' hearing threshold, and hence evaluates the level of sound a species can perceive, rather than its absolute level. It is critically important to judge the effects of noise reduction of seismic sources in this way, because a modification that reduces the level of high-frequency noise, for instance, may well reduce its "loudness" for a high-frequency hearer such as many marine mammals. The peak level may, however, be unaffected, or even, as in the experiments reported here, increased.

Measurements were made at Vobster Inland Diving Quay, a water-filled former quarry near Mells in Somerset, of the pressure time history generated by an airgun with and without a compliant silencer. The silencer was intended to reduce the high-frequency components that marine mammals can hear, while leaving the low frequency components used for seismic exploration unchanged. It was found that the broadband (chiefly low frequency) output of the airgun was actually consistently higher, by about 3 dB on average, for the results with the silencer. However, there was an associated reduction in level of the airgun at low operating pressures in terms of its dB_{ht}(*phoca vitulina*) value, and hence in its effects on a seal, of about 6 dB. At the higher discharge pressures the silencer material was thought to be collapsed by the airgun discharge, causing it to become relatively rigid, hence having less effect on the acoustics of the airgun. The silencer was thus beneficial for both seismic surveying and for the environment.

While the reduction achieved by the airgun silencer was modest, and, it is thought, well below that potentially achievable, a 6 dB reduction in dB_{ht} level represents a 4-fold reduction in the area of sea in which a seismic survey might have a given effect on a marine mammal, or 12-fold for an airgun array of constant Source Level if the increase in Source Level, and consequent reduction in the number or power of airguns required, is taken into account.

The concept of the low impact seismic array (LISA) was based on the use of inexpensive but powerful and rugged electromagnetic projectors to replace airgun arrays. The prospective benefit was that since the signal could be well controlled, both in frequency content and in the direction in which the sound propagated, the possibility existed of undertaking seismic surveys in environmentally sensitive areas with little or no collateral environmental impact.

The LISA project embodied the idea of using a large array of small but powerful electromagnetic projectors to replace airgun arrays. Initial measurements were made on a small (n=4) array of existing electromagnetic transducers designed by Subacoustech. It was found that a Source Level of about 142 dB re 1 μPa per volt @ 1 metre was achieved, at a peak frequency of 25 Hz. The operating frequency could be reduced to under 10 Hz with reasonable modifications, allowing use of an array for seismic exploration. The results indicate that it would be possible to achieve an array Source Level of about 223 dB re 1 μPa @ 1 metre, which is adequate for seismic surveying.

In summary, both of these technologies have significant prospective benefits in respect of reducing environmental effects during seismic surveying. In the case of the airgun silencer, the technology has additional benefits for seismic surveying, as it increases the level of the airgun while simultaneously reducing its environmental effect on marine mammals.

Fibre optic receivers and their effect on source requirements

P. Nash, A.V. Strudley, Stingray Geophysical

There is growing interest in the use of Seismic Permanent Reservoir Monitoring to maximise recovery and optimise production by time-lapse reservoir monitoring. In comparison to repeat towed streamer surveys, such systems offer greatly improved repeatability, better seismic signal/noise, and provide additional value from the direct recording of the full 4C vector wave-field. Seabed arrays based on

fully fibre optic sensing and telemetry are particularly attractive for this application because of their increased reliability and relative ease of deployment and operation compared to electrical systems.

The characteristics of fibre-optic seismic PRM systems result in different seismic source requirements compared to conventional systems as described below:

Reduced amplitude: Permanent seabed systems typically achieve better signal to noise ratio than towed streamer systems because the receivers are directly coupled into the seabed and hence are not subjected to towing or weather induced noise. Also, the signal is only subject to one-way transmission loss in the water column. Further fibre-optic sensors have high sensitivity which, together with the lower noise floor results in reduced requirements for high amplitude sources. For these reasons, seismic Permanent Reservoir Monitoring (Seismic PRM) has so far been conducted with relatively small seismic airgun sources –typically, a towed airgun array with around 70 bar-m p-p output (0-128Hz).

Reduced airgun volume: Typically, large volume airguns are used in the array for improved low frequency content. With fibre-optic seismic PRM the availability of pressure and acceleration measurements allows improvement in the low frequency performance by combination of the two wave-fields up to the limit imposed by the low frequency noise floor. The use of accelerometers rather than velocity sensors avoids a low frequency limitation in sensor bandwidth associated with sensor resonance (typically 10 -15Hz for a velocity sensor). Hence the requirement for large airgun volumes may be reduced, with beneficial effects across the whole source bandwidth.

Reduction in total survey duration: Because the receiver array is permanently deployed total survey time is reduced compared to towed streamer surveys because no infill is needed and weather downtime is minimised. In areas where Ocean Bottom Seismic is required (e.g. for 4C data), there is no requirement for repeated shots at the edges of the receiver spread unlike the case for retrievable systems. Hence, for the same shot coverage, the total number of shots is likely to be reduced.

Reduced high frequency bandwidth: Fibre-optic hydrophones and accelerometers are very broadband sensors with responses into the 10s of kHz range. Typical airgun sources have appreciable energy output at these frequencies and hence the receivers require a large top end system dynamic range (typically ~ 180dB) to avoid sensor saturation. Significant efficiencies in fibre-optic architectures, which would result in reduced receiver array cost, could be gained if this dynamic range requirement were reduced. Hence a seismic source array with reduced high frequency output is desirable.

In summary, Seismic PRM based on fibre-optic technology is likely to be of increasing importance in the near future for improved reserves recovery. Such systems offer a number of potential opportunities for optimisation of seismic survey source requirements and in particular would benefit from reduced high frequency airgun source output, such as a marine vibrator or other non-impulsive, oscillating sources.

Alternatives to Acoustic (Seismic) Geophysical Data Collection

Ron Brinkman, Minerals Management Service

Minerals Management Service (MMS) is a bureau of the Department of the Interior. Its mission is to manage the mineral resources of the Outer Continental Shelf in an environmentally sound and safe manner.

The collection of geophysical and geological data is critical for the MMS to fulfill its mission in helping meet our Nation's energy needs. However, the approval of seismic data collection activities must be considered in conjunction with concerns over the impact of these activities on the environment. These concerns are largely focused on sound introduced into the environment from seismic surveys and related activities (i.e., icebreaking, support vessel traffic, and aircraft over flights) and the effects of this sound on marine life and resources.

The issue of effects is further heightened by the lack of scientific certainty on the true impacts, the level of significance of these effects, and the ever increasing public scrutiny over these concerns. Despite these challenges, MMS is still charged with making decisions using the best available information. This leads to more conservative protective measures, additional mitigation and monitoring requirements, public criticism of environmental analyses and decision making, increased litigation, greater uncertainty on costs and risks for companies wanting to conduct seismic activities, impacts to access, and additional costs and delays in agency programs.

Ultimately, MMS must ensure that all seismic survey activities it regulates are in full compliance with all relevant environmental statutes and requirements. It is, therefore, imperative that MMS re-examine its processes for addressing seismic survey activities, both regionally and nationally, to identify where full environmental compliance is not yet reached and develop a plan forward to more effectively integrate seismic surveying and environmental compliance needs in light of these many challenges.

MMS is currently undertaking NEPA mandated geological and geophysical (G&G) Environmental Impact Studies (EIS) in all Regional Offices to determine compliance with call existing Laws. MMS is concurrently studying potential methods of noise reduction to existing seismic surveys. Samples of these studies include the following alternatives:

- ◊ Attenuate lateral noise with air bubble curtains, like has been shown in the literature, or with some special bubble curtain material, acting as a more solid (like a curtain) barrier;
- ◊ Make arrays more vertically directional, and thus narrow the cone of sound;
- ◊ Change the structure of the airguns to reduce high frequency sound (noise) while maintaining the strong source signal and low frequency source needed for exploration.

For more technical assessment and research studies see: http://www.mms.gov/tarprojectcategories/

STIFTUNG FÜR DAS MEER
okeanos

okeanos - Stiftung für das Meer
Auf der Marienhöhe 15
D-64297 Darmstadt
Telefon +49- 6151-918 20 23
Telefax +49- 6151-918 20 19
mail@okeanos-stiftung.org
www.okeanos-stiftung.org

October 11, 2012

Michael Payne, Chief Permits and Conservation Division
Office of Protected Resources, NOAA Fisheries
1315 East West Highway
Silver Spring, MD 20910
Sent via *email:* *ITP.Goldstein@noaa.gov*

By Electronic Mail

RE: Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Greenspace Mission: The North Coast area of San Luis Obispo County is a national treasure. Greenspace will protect and enhance its ecological systems, cultural resources and marine habitats through land acquisition and management, public education and advocacy.

Greenspace was an active advocate for the establishment of Marine Protected Areas for the Central Coast. Pt. Piedras Blancas State Marine Reserve, the Cambria State Marine Park, White Rock (Cambria) State Marine Conservation Area, Pt. Buchon State Marine Reserve and Pt. Buchon State Marine Conservation Area were created under the MLPA as areas for habitat protection and ecosystem based management of species.

Thanks to a decision by CA State Lands Commission and increasing citizen awareness and opposition this project has been significantly reduced in size and scope. Northern Zone Box 3 (Cambria State Marine Park and White Rock State Marine Conservation Area) was eliminated, the time frame was reduced to Nov. 1 thru Dec. 31, 2012, and the project will be phased over several years. The most recent report now describes the proposed 3D seismic survey race track to be completed during the 2012 survey period will be Box 4 which is located within Estero Bay.

Boxes 1 and 2 have been deferred and will be scheduled for the 2013-2014 work window. Refinement of the Box 1 and 2 survey components will be completed following the 2012 survey and will be subject to a supplemental review process. **Central Coastal California Seismic Imaging Project 1.0 Expanded Project Description Revision No. 9 9-28-2012.**

Greenspace respectfully asks your agency to continue to hold this project to the highest levels of scrutiny. Attached are three documents we wish to include for your consideration:

1. Report on Alternative Technologies to Seismic AirGun surveys for Oil and Gas Exploration and their potential for reducing Impacts to Marine Mammals by Okeanos Foundation for the Sea 2009
2. Effects of Anthropogenic Sound on Marine Mammals written by former CA Coastal Commissioner Sara Wan.
3. Cumulative Impacts of Noise with other stressors on Marine Mammals Okeanos Foundation for the Sea 2009

These three documents contain recommendations on alternatives to airguns that are available today, and detailed policy recommendations and analysis of harmful Seismic Survey noise effects, as well as cumulative effects of noise on Marine Mammals. Please apply the careful analysis of experts in their respective fields, and years of work and research that have contributed to this vast body of knowledge to this project. Policy considerations and recommendations contained in these documents must be firmly in place prior to projects such as this one.

We love our coast and thank you in advance for protecting it for future generations.

Mary Webb VP
Greenspace – the Cambria Land Trust

Richard Hawley, Exec. Director
Greenspace-the Cambria Land Trust

cc: Cassidy Teufel cteufel@coastal.ca.gov
Jennifer DeLeon- State Lands Commission Jennifer.DeLeon@slc.ca.gov
Becky Ota –CA Dept. of Fish and Game BOta@dfg.ca.gov
Holly Smith National Science Foundation hesmith@nsf.gov
Meagan Cummings Lamont Doherty cummings@ldeo.columbia.edu
Monica DeAngelis NOAA Monica.DeAngelis@noaa.gov
Lillian Carswell Lilian_Carswell@fws.gov
Rick Farris US Fish and Wildlife Rick_Farris@fws.gov
Charlton Bonham, Director Dept. of Fish and Game Director@dfg.ca.gov
Doug Barker CA State Parks DBarker@hearstcastle.com
Dr. Mary Gleason The Nature Conservancy mgleason@tnc.org

ITP Goldstein <itp.goldstein@noaa.gov>

(no subject)

Matthew Ininns <mattininns@gmail.com> Mon, Sep 24, 2012 at 12:56 AM
To: ITP.Goldstein@noaa.gov

To Michael Payne and whom ever it may concern at the NOAA,

I beg you to save the Point Buchon State Marine Reserve and stop PG&E's proposed seismic testing for the Diablo Canyon plant. PG&E's testing threatens to kill an irreplaceable amount of wildlife that has been pledged protected by law. How can you allow PG&E to proceed when there are other options to do this type of research? Too much is at stake to shamelessly destroy one of the most beautiful marine areas of the California coast. The amount of sea life lost, the damage to local fishing and outdoor sport economies will be massive, and PG&E's proposed compensation payments will only aide short term losses. Please DO NOT ALLOW PG&E to proceed with their seismic testing!

Thank you for your time,
Matt Ininns, San Luis Obispo, CA.

Howard Goldstein <howard.goldstein@noaa.gov>

Fwd: Seismic testing Central Coast

Pr Webmaster <pr.webmaster@noaa.gov> Thu, Sep 13, 2012 at 5:07 PM
To: Howard Goldstein <howard.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Mayra Clingman** <mayra365@gmail.com>
Date: Thu, Sep 13, 2012 at 4:41 PM
Subject: Seismic testing Central Coast
To: pr.webmaster@noaa.gov

Dear NOAA,

Please seriously reconsider allowing the seismic testing at the Central Coast.

The potential "benefits" are so incomparably small in contrast to the potential harm, disruption, and danger that will likely be caused. It is of huge importance to the people who live in the area, those who frequent it, those who benefit from the ocean and its beauty, those who desire future people to have the same benefit as we currently do and have.

If nothing else, please allow time for more people to provide input.

Sincerely,

Mayra M. Clingman

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Melinda <MelindaBray@earthlink.net>
To: ITP.Goldstein@noaa.gov

Sun, Oct 14, 2012 at 1:04 PM

ATTN: P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service.

Regest permit be denied based on following concerns:

1. Proposal downplays the potential effect on marine life including fish, invertebrates and marine mammals.

2. Important studies that linked seismic surveys to strandings are not mentioned in proposal. Specifically the report by Gentry (2000) called "**Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000**" is not mentioned, let alone discussed in detail. Report by Malakoff 2002 called **"Suit ties whale deaths to research cruise"** only mentioned briefly without significant discussion. Other occurrences such as Madagascar stranding are not mentioned at all.

These are documented cases that have not been mentioned in proposal (read more detailed description in our previous **post**):

1. Mozambique 2006,

2. Gulf of California, 2002

3. Galapagos Islands, 2000

4. Madagascar, 2008

5. Peru, 2012

6. Interesting Statistics from Australia (2002-2004)

3. Crucial study that showed cardiorespiratory changes in beluga whale in response to acoustic noise is not even mentioned in proposal (**link**). In this study belugas were exposed to noise at much lower level than is planned in California and the animal demonstrated severe tachycardia "at lower noise intensities (as low as 140 dB);"

4. This proposal is rushed and the levels of impact are not investigated enough and not accessed based on the best scientific evidence available.

5. The company's planned actions lack transparency, they should be required to fully and publicly disclose where activities take place, what equipment will be used, exact Sound Pressure Levels, when activities will take place. Additionally, marine mammal observers logs where they record all marine mammal sightings should be publicly available.

6. The proposal lacks specifics of how strandings will be investigated. It does not include what protocol of stranding investigation will be, what independent organizations will investigate strandings, who and in what manner will look for the evidence of acoustic trauma, decompression sickness related embolism, hemorrhage, etc.

7. NMFS should deny the permit based on omission of the best scientific evidence available and inadequate assessment of impact on marine life.

Thank you,

Melinda Bray

ASE "HELP" Assembly Bill 1632 (BLAKESLEE)

Taking exception

What effect will 250 decibels have on marine life off the Central Coast?

BY NEW TIMES STAFF

What's "a little louder than a rock concert" (according to PG&E), is going to cost PG&E ratepayers $64 million, and has detractors threatening to strap themselves to a whale to prevent it, if necessary?

If you answered PG&E's proposed seismic testing, scheduled to take place off the shores of the Central Coast in November, you'd be correct. But even if you happen to know that the California State Lands Commission has already approved the project, and that the California Coastal Commission is slated to either approve or deny the studies in mid-October, you probably still have some questions. Even if you know that the testing will consist of air guns affixed to the back of a research vessel firing into the water and measuring the blasts reflected off the seafloor, you still have questions, like:

How will the testing effect the fishing industry in Morro Bay?—a concern that prompted the Morro Bay City Council to condemn the tests. What will blasts reaching up to 250 decibels do to the marine life off the Central Coast? What does the draft environmental assessment released by the National Science Foundation mean when it lists 3,736 Morro Bay harbor porpoises, a species exclusively found locally (among dozens of other species, totaling thousands of marine mammals) as the take for the studies?

By its own admission, the National Science Foundation can't explain to *New Times* what "take by harassment" means, which makes the assessment it's mulling over more alarming than useful.

So take the numbers below (pulled directly from the National Science Foundation's environmental assessment) with a gra of salt—because we can't tell you what it all means, because we can't numbers in some kind of reasonable context, and because the regulat required to approve this project seem shockingly comfortable with th

Here are the numbers we've found, ranging from 11 humpback Morro Bay harbor porpoises. We wish we could tell you what it a the coming weeks, we'll continue to try. Δ

Send comments to Managing Editor Ashley Schwellenbach at asc newtimesslo.com.

California Gray Whale

Eschrichtius robustus

x10 = 78

mic testing—a
enefit not only the
nity, but the residents
ll.
lifornia's marine
the Coastal
sions. Pacific Whale
alf of our thousands of
the world, thus urges
aluate the long-term,
ences associated with
g, and in doing so,
sultant irreversible
nia's marine life
eighs testing.

Lauren Campbell
Conservation Manager
cific Whale Foundation

ative Pismo refreshing

refusing to honor its
ntract with LAFCO.
ismo being sued by
rance carrier. This
hen Pismo was not
LAFCO over its work
Del Mar application.
ill lead to LAFCO
any more applications
is unprecedented.
evant because Pismo's
-established reputation
ose at its neighboring
encies like LAFCO
ommission. It has also
bligations to Lucia Mar
elopment monies.
ative to the county,
quite frankly,
it's why I am urging
support Erik Howell
or council. Not only
present the concerns of Pismo's residents, but they will encourage a new cooperative spirit in the city's government. That would be very refreshing.

Supervisor Adam Hill
District Three
San Luis Obispo County

On Capps and taxes

Have you heard the misleading ad against Congresswoman Lois Capps? The truth is she once rented a room to a staffer for low rent and did not think to report this small amount of income. When she did, she voluntarily paid the extra tax. Her opponent is being pursued by the IRS for an enormous amount.

Capps did not raise your taxes. She voted to *reduce* payroll taxes for 95 percent of employees and employers.

The ad calls the $90-a-year penalty for refusing to buy health insurance when you can afford it "the biggest tax increase ever."

Pearl Munak
Paso Robles

How to change America, starting at home

Acknowledge the political process needs to change.

Abandon the two party/two platform system of entrenched ideals.

We need a more open, level, and varied field of candidates and ideas. The political system needs to nurture citizen politicians. Politics should be viewed as public service, taking your turn and then stepping aside. If more people participated in government, maybe there would be a wider spread understanding of how it works.

Here is how to do it with a simple social contract:

Candidates never ask for votes, but simply share their beliefs and ideas.

Incumbents and challengers run as write-in candidates; no names on ballot to bubble in.

There should be minimal campaigning during election season—debates and personal appearances only. Also, minimal public outreach through ads, billboards, mass mailings, and commercials. Homemade yard signs at residences would be encouraged, as would website/YouTube postings where people can voluntarily find information on the candidate.

Campaign expenditures shoul
kept to a minimum, and expendi
campaigns must be matched by a
contribution to charity.

Steve

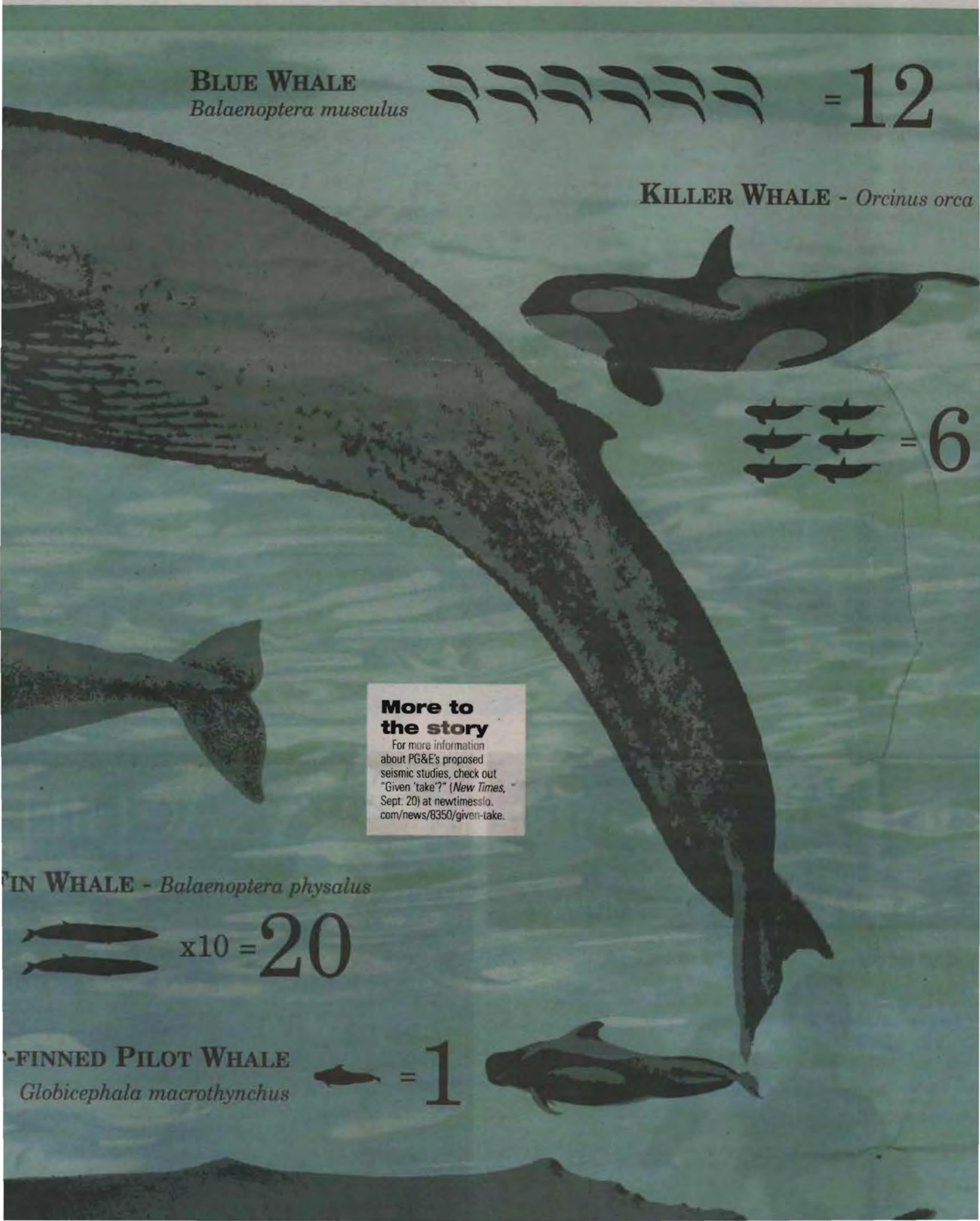
Jerry James

letters

Please include your name a
Keep letters to 250 words. Send
New Times Letters, 1010 Ma
San Luis Obispo, CA 93401, or
letters@newtimesslo.com. All letter
the property of *New Times*. We re
right to edit for length and clarity.
letters appear and are archived on
Times website as well as in print.

The Great American
MELODRAMA
& VAUDEVILLE
Sheer-Luck Holmes
Followed by an all new

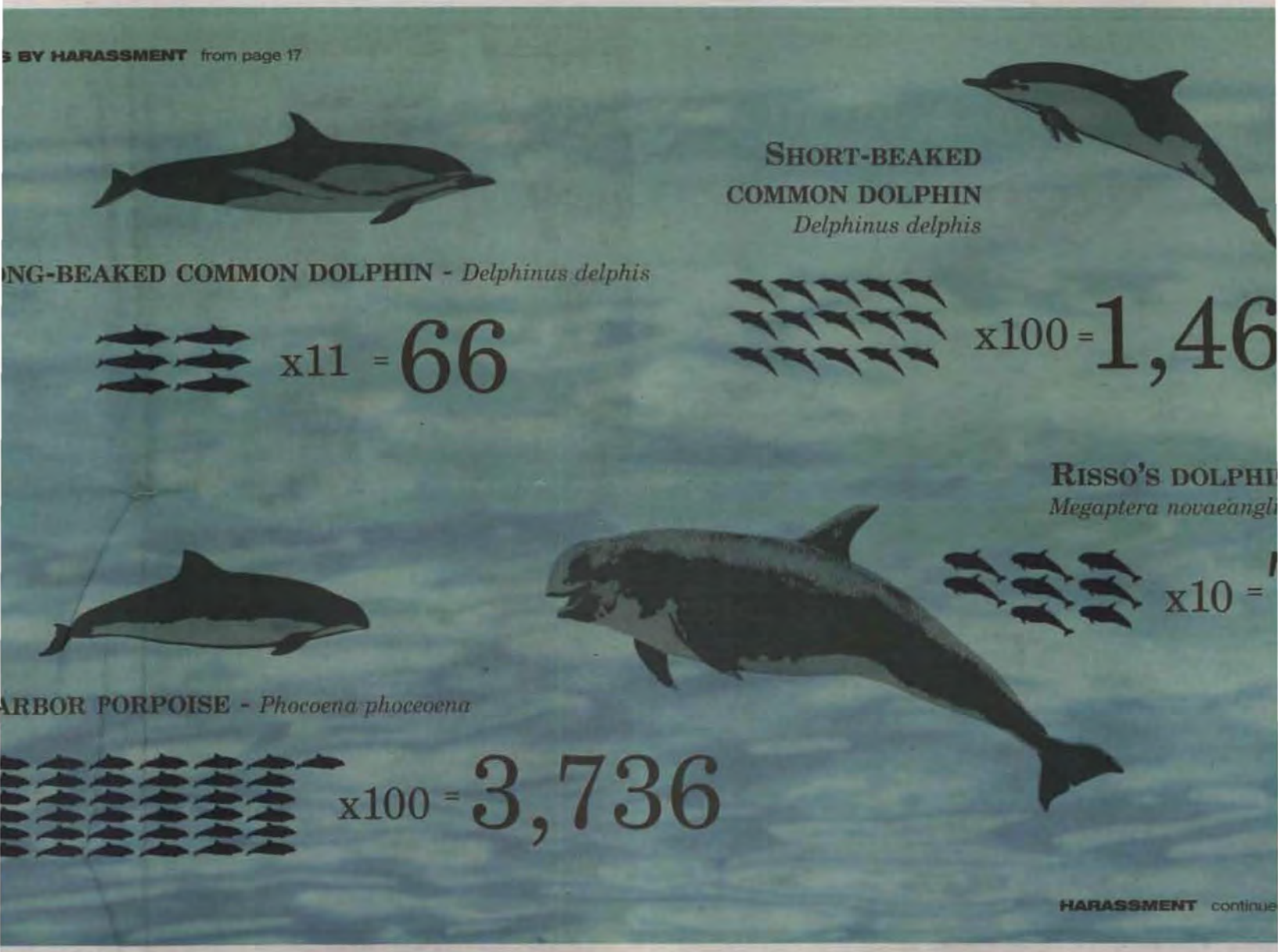
Did You Know?
The Center for Health & Prevention o
- *STI testing and treatment*
- *Male Services*
- *Birth Control Methods*
- *Pregnancy testing & counseling*
- *Emergency Contraception*
- *Mid-life Services*



More to the story

For more information about PG&E's proposed seismic studies, check out "Given 'take'?" (*New Times*, Sept. 20) at newtimesslo.com/news/8350/given-take.

S BY HARASSMENT from page 17



HARASSMENT continue

alling All Students!

Local Moving & Packing Company

lust Fill Over 25 Positions Immediately

THEAD MOVER...

carries household
mercial goods to
n the moving truck

henever *not*
items

eous, customer
oriented and
sitive attitude

A PRINCESS PACKER...

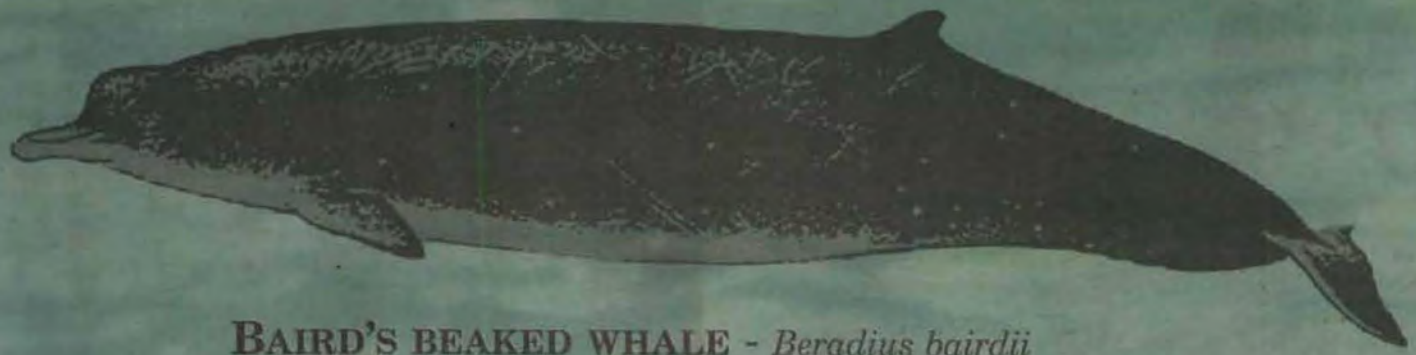
- Packs, organizes, and unpacks household and commercial goods
- Works either on-site at a client's home or office, or at the corporate office
- Is friendly, clean-cut, polite and organized

ACHILL
PROSTHETICS AND ORTH
WITH OFFICES IN SLO & SANTA MARI
SERVING THE CENTRAL COAST S

ACHILLES IS PLEASED TO ANNOUNCE A GREAT NEW ADDITION TO THEIR FULL-TIME SLO STAFF, LAURA SO C.P.O., A.B.C. CERTIFIED PROSTHESIST & ORTHOTIST WITH OVER 11 YEARS OF EXPERIENCE. LAURA BRINGS WITH HER A CARING AND COMPASSIONATE APPROACH TO PATIENT CARE.

CALL TODAY FOR A NO-COST, NO-OBLIGATIO

ES BY HARASSMENT from page 19



BAIRD'S BEAKED WHALE - *Beradius bairdii*

=2

SMALL BEAKED WHALE - *Ziphius cavirostris*

= 7

NORTHERN RIGHT WHALE DOLPH

Lissodelphis borealis

x10 =9

IFORNIA SEA LION - *Zalophus califorianus*

x100 =849

HARASSMENT from page 18

TTLENOSE DOLPHIN - *Tursiops truncatus*

x 10 = 1,324

TRIPED DOLPHIN - *Stenella coeruleoalba*

=7

PACIFIC WHITESIDED DOLPHIN

Lagenorhynchus obliquidens

x10 = 152

supper
at suns

wine and dine under the
in our chefs garden

Chef Robert will be preparing his ga
spired menu for you in the garden to y

Exclusive once a year dinner in our
garden-limited to 30 guests. Family-s
paired with fine local wines. Live acous

Friday, October 5th, 5-8
wine reception 5-5:30pm, dinner 5:

sycamore garden
herbs, flowers, tomatoes, beans squash, radish, greens
2012 Sauvignon Blanc, Dragonette Cellars, Santa Ynez

smoked white quinoa
shaved melon, cucumber, apple, poached heirloom tomatoes, nastu
2009 Kynsi Pinot Blanc, Bien Nacido Vineyard, Santa Maria Vall

garden herb and lemon stuffed whole bass
spaghetti "a la chittara" fennel, tomato, jalapeño, basil, bread crum
2010 Laetitia Pinot Noir, Estate

grilled pork tenderloin
tomato seed mustard, crisp summer beans, charred eggplant pur
2008 Baker & Brain Syrah, Paragon Vineyard, Edna Valley

fresh goat cheese cannoli
goat cheese custard, tomato, almond, orange
2011 Wolff Riesling, Estate

$85 per person *includes wine, tax, and gratuity.*

SYCAMORE
MINERAL SPRINGS
RESORT & SPA
EST. 1886

ode to tomatoes — Sycamore Chef
1215 Avila Beach Drive · sycamorespring
reservations required, call directly 540.
menu subject to change without notice due to the gardens natur

HunterDouglas
holiday
style
event

Comfort and

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Stop Seismic Testing, and stop the pre-work (traumatizing of marine mammals)

Howard Goldstein <howard.goldstein@noaa.gov> Tue, Oct 16, 2012 at 9:05 AM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Meredith McCown** <Meredith.McCown@yahoo.com>
Date: Mon, Oct 15, 2012 at 11:29 PM
Subject: Stop Seismic Testing, and stop the pre-work (traumatizing of marine mammals)
To: "Howard.Goldstein@noaa.gov" <Howard.Goldstein@noaa.gov>

The baselines are shifted, the whales are endangered already, seismic testing does nothing to improve our safety, and the Harbor Porpoises and Otters could be rendered completely extinct if this unnecessary seismic testing is allowed to go forward.

Meredith McCown
Morro Bay, CA

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

ITP Goldstein <itp.goldstein@noaa.gov>

michael g.....

Michael Golembeski <michael@wind-dancer.org> Sun, Oct 14, 2012 at 6:37 PM
To: ITP.Goldstein@noaa.gov

I can't believe that a government agency has the "God" given right to kill marine life at the levels this action of testing will do..... its not even a "national security issue" just pure nonsense and no way to ask in a kind way but NOT TO.....

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Seismic testing

Howard Goldstein <howard.goldstein@noaa.gov> Mon, Oct 15, 2012 at 8:10 PM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Michael J Phillips** <phillips.michael07@gmail.com>
Date: Mon, Oct 15, 2012 at 8:07 PM
Subject: Seismic testing
To: "howard.goldstein@noaa.gov" <howard.goldstein@noaa.gov>

Please STOP the seismic testing in our waters.

Thank you

Brother Michael OCS

Sent from the iPhone of Michael J. Phillips peace and love

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

ITP Goldstein <itp.goldstein@noaa.gov>

Comments on Diablo Canyon IHA

Jasny, Michael <mjasny@nrdc.org> Mon, Oct 15, 2012 at 6:09 PM
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>
Cc: "Garrison, Karen" <kgarrison@nrdc.org>, Kaitilin Gaffney <kgaffney@oceanconservancy.org>, Jenn Feinberg Eckerle <jennfeinberg.nrdc@gmail.com>

Dear Howard, Mike, and Jolie:

Please find attached our comments on the Proposed IHA for the Diablo Canyon seismic survey, with two enclosures. Please don't hesitate to contact me if you have any questions or any problems with the files.

Sincerely,

Michael

Michael Jasny

Senior Policy Analyst

Director, Marine Mammal Protection Project

Natural Resources Defense Council

4479 W. 5th Avenue

Vancouver, BC V6R1S4

tel. 604-736-9386

mob. 310-560-5536

fax 310-434-2399

mjasny@nrdc.org

3 attachments

Proposed IHA comments. NRDC and OC. 15Oct12.pdf

271K

PGE Letter DCL-2012-648.pdf
972K

NRDC OC cmmt update to CCC Diablo Seismic final 9'21'12.pdf
790K

Pacific Gas and Electric Company®

Diablo Canyon Power Plant P. O. Box 56
Avila Beach, CA 93424

October 2, 2012

PG&E Letter DCL-2012-648

Mr. Cassidy Teufel
California Coastal Commission
45 Fremont Street 2000
San Francisco, CA 94105- 2219

Coastal Development Permit Application No. EA-12-005
Updated Expanded Project Description

Dear Mr. Teufel:

Pacific Gas and Electric Company (PG&E) Letter DCL-2012-614, dated April 12, 2012, submitted a complete Coastal Development Permit application package for the Offshore Central Coastal California Seismic Imaging Project (Project).

Based on feedback from your staff and to address community feedback regarding the proposed high-energy offshore seismic study neat Diablo Canyon Power Plant, PG&E is enclosing an updated Expanded Project Description for consideration during the California Coastal Commission's November 2012 meeting.

Please contact me should you have any questions regarding this submittal.

Sincerely,

L. Jearl Strickland
Director, Nuclear Projects
805-781-9785 (office)
805-441-4208 (cell)
LJS2@pge.com (email)

Enclosure

Central Coastal California Seismic Imaging Project
Updated Expanded Project Description
Revision No. 9

1.0 UPDATED EXPANDED PROJECT DESCRIPTION

The following updated project description was prepared by Pacific Gas and Electric Company (PG&E) in support of the proposed Offshore Central Coastal California Seismic Imaging Project (Project). This update reflects additional revisions to the project that have resulted during the permitting process, including the California State Lands Commission (CSLC) project approval which resulted in the elimination of portions of the originally planned survey area (Survey Box 3) and the extension of the project to a two-year work window. Additional revisions outlined in this updated project description have been developed in response to discussions with National Marine Fisheries Service (NMFS), United States Fish and Wildlife Service (USFWS) and California Coastal Commission (CCC). All Project related activities will occur within the central area of San Luis Obispo County, California (Figure 1-1). The following summarizes the proposed offshore deep seismic data collection survey operations proposed for 2012.

1.1 PROJECT TITLE

Offshore Central Coastal California Seismic Imaging Project

1.2 PROJECT APPLICANT'S NAME AND ADDRESS

Pacific Gas & Electric Company
Mr. Jearl Strickland, Director, Nuclear Projects
Diablo Canyon Power Plant
Mail Code 104/6/602C
Post Office Box 56
Avila Beach, California 93424

1.3 PURPOSE AND OBJECTIVES

The purpose of the proposed survey is to conduct additional seismic studies in the vicinity of the Diablo Canyon Power Plant (DCPP) and known offshore fault zones near DCPP. These seismic studies will provide additional insights of any relationships or connection between the known faults as well as enhance knowledge of offshore faults near DCPP. The proposed deep (10 to 15 kilometers [km] or 6 and 9 miles [mi]), high energy seismic survey (HESS) (energy >2 kilo joules) would complement the shallow (< 1 km/0.6 mi), low energy (< 2 kilo joules) 3D seismic reflection survey. The first and second phases of low energy 3D seismic surveys were conducted offshore DCPP by PG&E in November 2010 and January 2011, respectively. The third and last phase of the low energy 3D seismic surveys is being conducted in late summer 2012.

The objectives of the proposed high energy 3D seismic survey are to:

- Record high resolution wide 2D and 3D seismic reflection profiles of major geologic structures and fault zones in the vicinity of DCPP.
- Obtain improved deep (>1 km [>0.6 mi]) imaging of the Hosgri and Shoreline fault zones in the vicinity of the DCPP to constrain fault geometry. (Scheduled for 2013 survey activities)

Figure 1-1. Proposed Project Survey Area

- Obtain improved (>1 km [>0.6 mi] depth) imaging of the intersection of the Hosgri and Shoreline fault zones northwest of Point Buchon.
- Obtain improved (>1 km [>0.6 mi] depth) imaging of the intersection of the Hosgri and Los Osos fault zones in Estero Bay.
- Augment current regional seismic data base for subsequent use and analysis.

The Project is being undertaken due to public concerns with operating a nuclear power plant in a seismically active area of California after the Fukushima Daiichi emergency. PG&E will obtain as much seismic information as possible, while minimizing environmental impacts consistent with the permits required by federal, state, and local agencies to conduct the studies. The Project timeframe is limited to fall months (November 1 to December 31 for active marine seismic survey operations) due to whale and fish migration as well as nesting bird constraints. The survey will also be conducted over a period of two years to reduce the extent of annual exposure of marine resources to high-energy seismic sound levels.

The current Project scope has been designed to minimize environmental impacts to the greatest extent feasible and has been modified to further recognize agency input and specific concerns regarding resident species of marine mammals within the survey area. PG&E is proposing to conduct the studies 24-hours per day, 7 days per week (24/7). This schedule is designed to reduce overall air emissions, length of time for operation in the water thereby reducing impacts to marine wildlife, commercial fishing, and other area users. PG&E will work with environmental agencies to appropriately address the balancing of public health and safety and environmental concerns during the conduct of these studies.

1.4 PROJECT LOCATION

The proposed Project would be conducted within the coastal (onshore and nearshore) and offshore marine waters between Morro Bay and San Luis Bay, offshore San Luis Obispo County, California (Figure 1-1). The proposed survey will cross all the major geologic units in the study area and image their structure at depth using high-resolution 2D and 3D seismic reflection profiling techniques. The offshore and onshore survey sound source transects, as well as the nearshore/onshore geophone locations, have been developed to address the project objectives as well as ongoing input from the California Public Utilities Commission's Independent Peer Review Panel (IPRP), the survey contractor (Lamont-Doherty Earth Observatory – Columbia University) and geoscientists from the University of Nevada – Reno, the Scripps Institute of Oceanography, and specialty private consulting firms.

1.5 3D SEISMIC DATA ACQUISITION TARGET AREAS FOR 2012

The proposed 3D seismic survey race track to be completed during the 2012 survey period will be Box 4 which is located within Estero Bay (See Figure 1-2). Boxes 1 and 2 have been deferred and will be scheduled for the 2013-2014 work window. Refinement of the Box 1 and 2 survey components will be completed following the 2012 survey and will be subject to a supplemental review process. Box 3 was eliminated from the survey plan based on input from the IPRP process and associated CSLC permit approval.

The offshore survey would be conducted in both federal and state waters and water depths within the proposed survey areas ranging from 0 to over 400 m (1,300 ft); the State

three-mile limit is the teal line in Figure 1-1. The Point Buchon Marine Protected Area (MPA) lies adjacent to portions of the survey area. The Monterey Bay National Marine Sanctuary (MBNMS), a federally-protected marine sanctuary that extends northward from Cambria to Marin County, is located north and outside of the Project area. The 2012 survey area includes:

Survey Box 4. (Estero Bay)

- Area: 334.48 km^2 (129.14 mi^2)
- Total survey line length is 1,417.6 km (880.9 mi)
- Dip line survey across the Hosgri and Los Osos fault zones in Estero Bay

Figure 1-2 shows the proposed survey transit lines for Box 4. These lines depict the survey lines as well as the turning legs. The full seismic array is firing during the straight portions of the track lines, as well as the initial portions of the run out sections and later portions of run in sections. During turns and most of the initial portion of the run ins, there will only be one air gun firing (mitigation air gun). Assuming a daily survey rate of approximately 8.3 km/hr (4.5 knots for 24/7 operations) Survey Box 4 is expected to be completed in approximately 9.25 days. When considering mobilization, demobilization, equipment maintenance, weather, marine mammal activity, and other contingencies, the proposed 2012 survey is expected to be completed in 32.25 days. For an in-depth look into the project schedule, refer to Section 1.8 - Project Schedule.

1.6 PROJECT ACTIVITIES

The proposed survey involves both marine and some limited onshore activities. The offshore components consist of operating a geophysical survey vessel and support/monitoring vessels within the areas shown in Figure 1-2. The geophysical survey vessel would tow a series of sound-generating air guns and sound-recording hydrophones along pre-determined shore-perpendicular transects to conduct deep (10 to 15 km [6 to 9 mi]) seismic reflection profiling of major geologic structures and fault zones in the vicinity of DCPP.

Onshore operations will involve the installation of passive acoustical receivers on the Morro Strand. Installation and retrieval of these seismic receivers would be concurrent with the proposed offshore operations.

1.6.1 Mobilization and Demobilization

The offshore 3D marine survey equipment and vessels are highly specialized and typically not available in California. The proposed seismic survey vessel (*R/V Marcus G. Langseth [R/V Langseth]*) is currently operating on the west coast and is available to conduct the proposed survey work. The *R/V Langseth* would transit south prior to the start of survey operations (November 1 through December 31, 2012). Once the vessel has arrived in the Project area, the survey crew, any required equipment, and support provisions would be transferred to the vessel. The proposed survey vessel is supported by a chaseboat (*R/V Nushagak Spirit or equivalent*) and scout/shore support boat (*M/V Enterprise or equivalent*). An additional scout/monitoring vessel, M/V *Michael Uhl (M/V Uhl),* is available locally and will be utilized to support operations as necessary. Upon completion of the offshore survey operations, the survey crew would be transferred to shore and the survey vessel would transit out of the Project area.

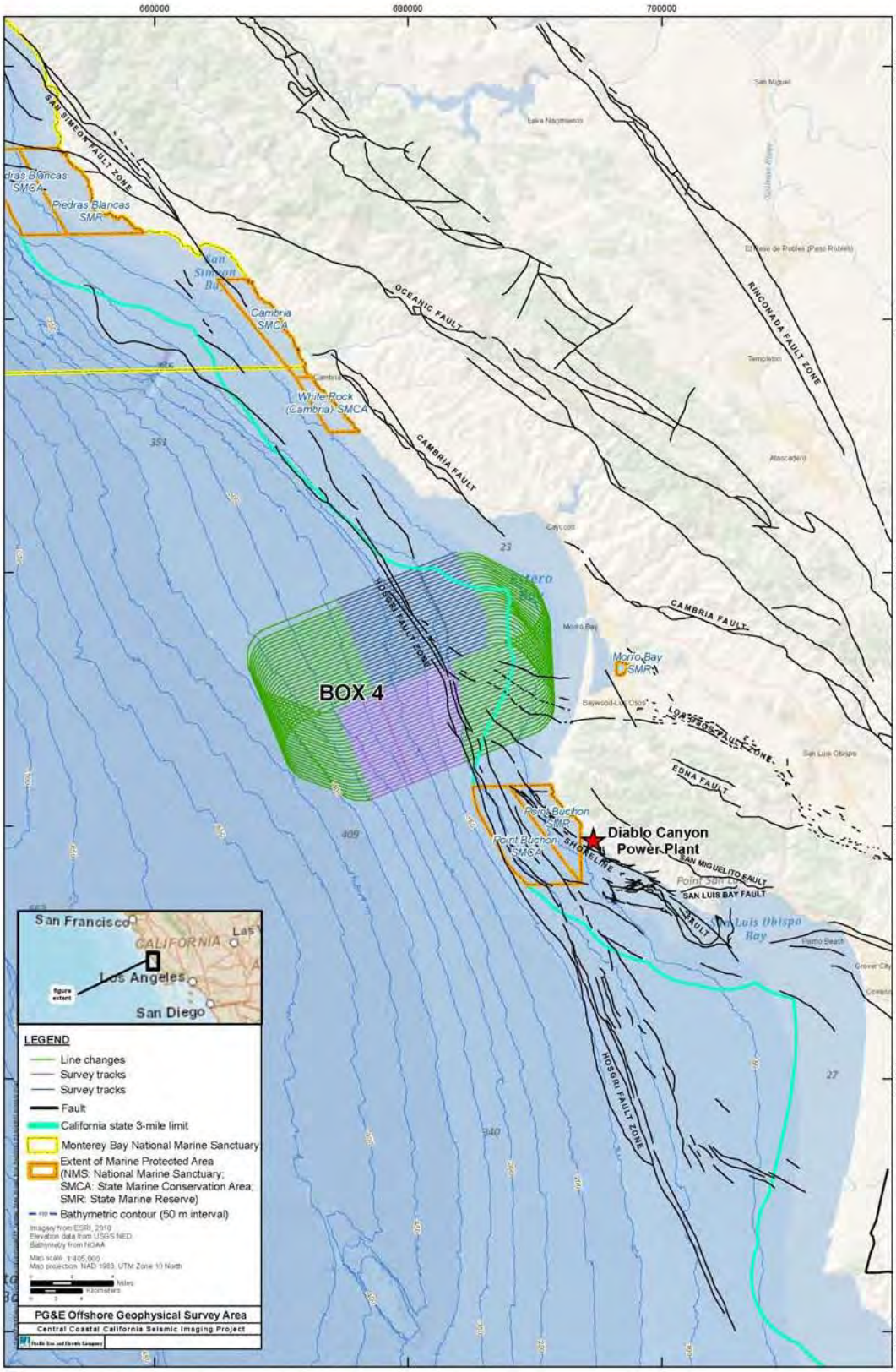


Figure 1-2. Proposed 2012 Project Survey Track Line Map

1.6.2 Offshore Survey Operations

The proposed offshore seismic survey would be conducted with geophysical vessels specifically designed and built to conduct such surveys. PG&E has selected the *R/V Langseth*, which is operated by the Lamont-Doherty Earth Observatory (Columbia University). The following outlines the general specifications for the *R/V Langseth* geophysical survey vessel and the support vessels needed to complete the offshore survey.

- Primary vessel – *R/V Langseth* is 71.5 m [235 ft] in length and is outfitted to deploy/retrieve hydrophone streamers and air gun arrays, air compressors for the air gun array, and survey recording facilities.
- Chase boat – *R/V Nushagak Spirit* is 33.5 m (110 ft) in length and will be deployed in front of the *R/V Langseth* to observe potential obstructions, additional marine mammal monitoring and support deployment of seismic equipment.
- Third vessel – *M/V Enterprise* is approximately 24.3 m [80 ft] in length and would act as a scout boat and support vessel for the *R/V Langseth.*
- Support work vessel – The *M/V Uhl* is approximately 30.5 m [100 ft] in length and would be used as a standby vessel to support marine operations.

Survey Vessel Specifications. The *R/V Langseth* would tow the air gun and hydrophone streamers array along predetermined lines (Figure 1-2). When the *R/V Langseth* is towing the air gun and streamer array the vessel will “fly” the appropriate USCG approved day shapes (mast head signals used to communicate with other vessels) and display the appropriate lighting to designate the vessel has limited maneuverability. The turning radius is limited to 3 degrees per minute (2.5 km [1.5 mi]). Thus, the maneuverability of the vessel is limited during operations with the streamers.

The *R/V Langseth* has a length of 71.5 m (235 ft), a beam of 17.0 m (56 ft), and a maximum draft of 5.9 m (19.4 ft). The *R/V Langseth* was designed as a seismic research vessel, with a propulsion system designed to be as quiet as possible to avoid interference with the seismic signals. The ship is powered by two Bergen BRG-6 diesel engines, each producing 3,550 hp, which drive the two propellers directly. Each propeller has four blades, and the shaft typically rotates at 750 revolutions per minute (rpm). The vessel also has an 800 hp bowthruster, which is not used during seismic acquisition. The operation speed during seismic data acquisition is typically 7.4 to 9.3 km/h (4.6 to 5.7 miles/h). When not towing seismic survey gear, the *R/V Langseth* typically cruises at 18.5 km/h (11.5 miles/h). Other details of the *R/V Langseth* include the following:

- Owner: National Science Foundation
- Operator: Lamont-Doherty Earth Observatory of Columbia University
- Flag: United States of America
- Date Built: 1991 (Refitted in 2006)
- Gross Tonnage: 3834
- Accommodation Capacity: 55 including ~35 scientists

Air Gun Description. The survey will be shot using two tuned air-gun arrays, consisting of two sub-arrays with 1,650 cubic inches (in^3). The array would consist of a mixture of Bolt 1500LL and Bolt 1900LLX air guns. The subarrays would be configured as two identical linear arrays or "strings" (Figure 1-3). Each string would have ten air guns; the first and last air guns in the strings are spaced 16 m apart. Nine air guns in each string would be fired simultaneously (for a total volume of approximately 3,300 in^3), whereas the tenth is kept in reserve as a spare, to be turned on in case of failure of another air gun. The subarrays would be fired alternately during the survey. Each of the two subarrays would be towed approximately 140 m (459 ft) behind the vessel and would be distributed across an area of approximately 12 by 16 m (40 by 50 ft) behind the primary vessel, offset by 75 m (250 ft). Discharge intervals depend on both the ship's speed and Two Way Travel Time (TWTT) recording intervals. For a 16-second TWTT, air guns will be discharged approximately every 37.5 meters (123 ft) based on an assumed boat speed of 4.5 knots. The firing pressure of the subarrays is 1,900 pounds per square inch (psi). During firing, a brief (~0.1 s) pulse of sound is emitted. The air guns would be silent during the intervening periods.

The tow depth of the air gun array would be 9 m (29.5 ft). Because the actual source is a distributed sound source (9 air guns) rather than a single point source, the highest sound levels measurable at any location in the water would be less than the nominal single point source level. In addition, the effective (perceived) source level for sound propagating in near-horizontal directions would be substantially lower than the nominal omni-directional source level because of the directional nature of the sound from the air gun array (i.e. sound is directed downward).

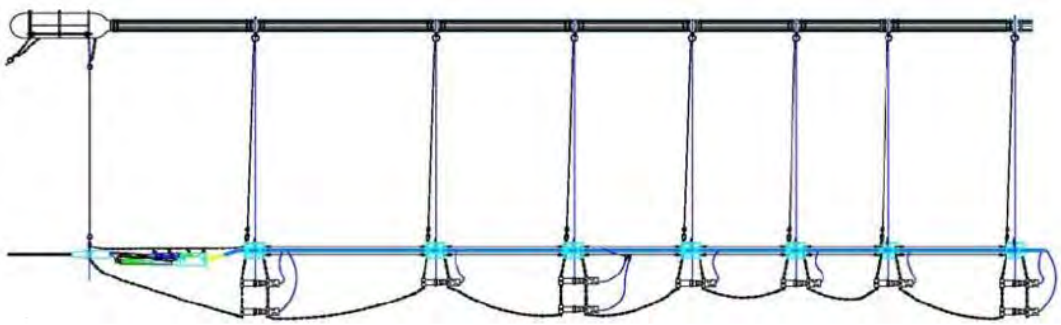


Figure 1-3. One Linear Air Gun Array or String with Ten Air Guns, Nine of Which Would Be Operating.

Details regarding the proposed 18-air gun array (2 Strings) specifications are as follows:

- Energy Source: Eighteen 2,000 psi Bolt air guns of 40-360 in^3
- Source output (downward): 0-pk is 42 bar-m (252 dB re 1 μPa · m); pk-pk is 87 bar-m (259 dB)
- Towing depth of energy source: 9 m (29.5 ft)
- Air discharge volume: ~3,300 in^3
- Dominant frequency components: 0-188 Hertz (Hz)

Compass Birds would be used to keep the air guns at a depth of 9 m (29.5 ft) and the vessel speed during data collection would range from 7.4 to 9.3 km/h (4 to 5 nautical miles per hour [knots]). The sound source would be generated by the discharge of the air guns approximately every 37.5 m (123 ft) which is based on an assumed vessel speed of 8.3 km/h (4.5 knots). The expected timing of the shots is once every 15 to 20 seconds.

Hydrophone Streamer Description. The *R/V Langseth* will tow four hydrophone streamers with a length of approximately 6 km (3.7 mi). The intended tow depth is approximately 10 m (32.8 ft). Each streamer would consist of Sentry Solid Streamer Sercel cable. Flotation is provided on each streamer, as well as Streamer Recovery Devices (SRD). The SRD are activated when the streamer sinks to a pre-determined depth (e.g. 50 m [164 ft]) to aid in recovery.

A series of seven hydrophones is present along each streamer for acoustic measurement. The hydrophones would consist of a mixture of Sonardyne Transceivers. Each streamer will contain three groups of paired hydrophones, with each group approximately 2,375 m (7,800 ft) apart. The hydrophones within each group would be approximately 300 m (984 ft) apart. One additional hydrophone will be located on the tail buoy attached to the streamer cable. In addition, one Sonardyne Transducer would be attached to the air gun array. Compass Birds would be used to keep the streamer cables and hydrophones at a depth of approximately 10 m (33 ft). One Compass Bird would be placed at the front end of each streamer. The Figure 1-4 depicts the configuration of both the streamer and air gun array used by the *R/V Langseth*.

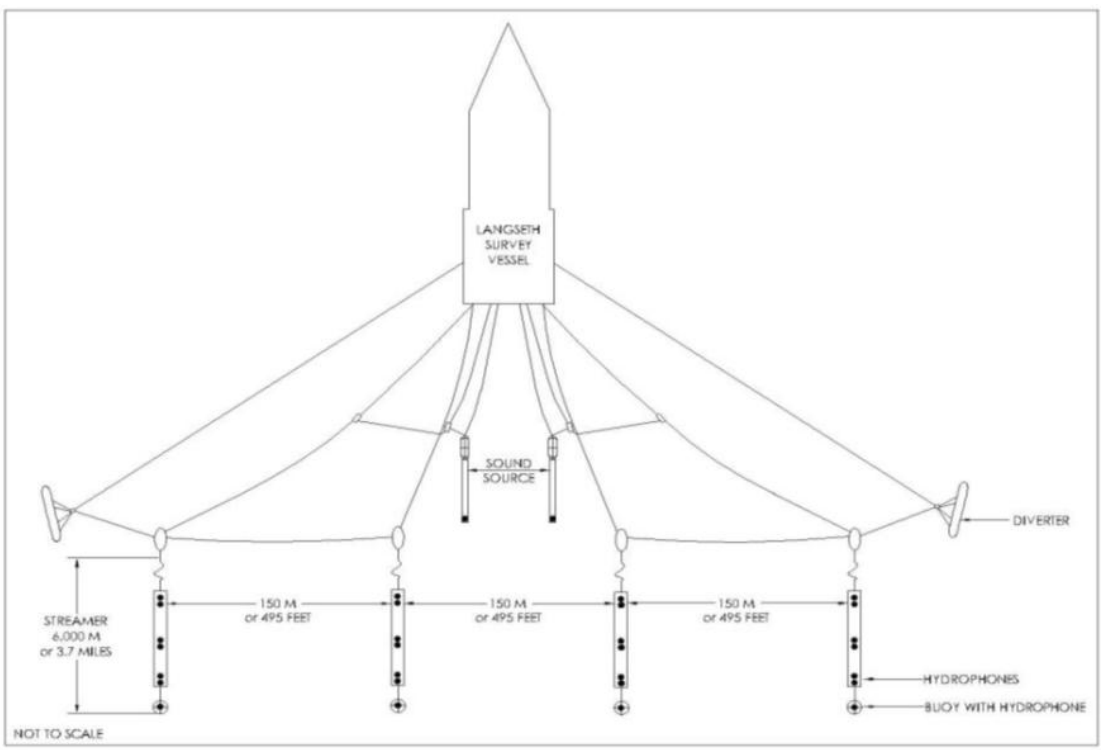


Figure 1-4. *R/V Langseth* Air Gun and Streamer Deployment

Details regarding the proposed hydrophone streamer and acoustic recording equipment specifications are provided in Table 1-1.

Table 1-1. Summary of Offshore Streamer Features

Hydrophone Type	**Sonardyne XSRS Transceiver 7885 (Standard)**
Length of Individual Unit (approximate)	85.8 centimeters (33.8 inches)
Diameter of Individual Unit (approximate)	7.5 centimeters (3.0 inches)
Weight of Individual Unit in Air (approximate)	7.3 kilograms (16.0 pounds)
Number of Units per String	5
Hydrophone Type	**Sonardyne XSRS Transceiver 8005 (Long Life)**
Length of Individual Unit (approximate)	91.1 centimeters (35.9 inches)
Diameter of Individual Unit (approximate)	8.9 centimeters (3.5 inches)
Weight of Individual Unit in Air (approximate)	10.4 kilograms (22.9 pounds)
Number of Units per String	2
Hydrophone Type	**Sonardyne HGPS Transducer 7887 (Right Angle)**
Length of Individual Unit (approximate)	56.3 centimeters (22.2 inches)
Diameter of Individual Unit (approximate)	9.4 centimeters (3.7 inches)
Weight of Individual Unit in Air (approximate)	9.6 kilograms (21.2 pounds)
Depth Sensor	**ION Model 5011 Compass Bird**
Length of Individual Unit (approximate)	120 centimeters (48.2 inches)
Weight of Individual Unit in Air (approximate)	8.32 kilograms (18.3 pounds)
Number of Units per Streamer (approximate)	4
Number of Units per String	1
Streamer Type	**Thompson Marconi Sentry**
Streamer Depth (approximate)	10 meters (33 feet)
Group Interval (approximate)	12.5 meters (41 feet)
Group Length (approximate)	12.5 meters (41 feet)
Number of Groups	468
Length of Streamer	6 kilometers (3.7 miles)

Source: Columbia University

Acoustic Measurements. The strength of the air gun pulses can be measured in a variety of ways, but National Marine Fisheries Service (NMFS) commonly uses “root mean square” (in dB re 1µPa [rms]), which is the level of the received air gun pulses averaged over the duration of the pulse. The rms value for a given air gun pulse is typically 10 dB lower than the peak level, and 16 dB lower than the peak-to-peak level (McCauley *et al*., 1998, 2000).

The noise modeling for the proposed 3D seismic survey was conducted based on the results of mathematical modeling conducted by Greeneridge Sciences, Inc. (2011). The model results are based upon the air gun specifications provided for *R/V Langseth* and seafloor characteristic available for the Project area. Safety and Exclusion zone dimensions are based on NMFS definitions for Incidental Harassment Authorizations (IHA). The Safety Zone is the distance within which received sound levels are modeled to be greater than 160 db and the Exclusion Zone is the distance within which received sound levels are modeled to be greater than 180 db. Distances to received levels of 120, 154, 160, 170, 180, 187, and 190 dB re 1µPa (rms) are also detailed in Table 1-2.

Table 1-2. Calculated Radii for Upslope, Downslope and Alongshore Propagation Paths

Sound Pressure Level (SPL) (dB re 1 uPa)	Upslope Distance (In Shore)			Downslope Distance (Offshore)			Alongshore Distance		
	M[1]	SM[2]	NM[3]	M[1]	SM[2]	NM[3]	M[1]	SM[2]	NM[3]
190	250	0.16	0.13	280	0.17	0.15	320	0.20	0.17
187	390	0.24	0.21	370	0.23	0.20	410	0.25	0.22
180	1,010	0.63	0.55	700	0.43	0.38	750	0.47	0.40
170	2,990	1.86	1.61	1,760	1.09	0.95	1,760	1.09	0.95
160	6,210	3.86	3.35	4,450	2.77	2.40	4,100	2.55	2.21
154	8,570	5.33	4.63	7,820	4.86	4.22	6,780	4.21	3.66
120	24,650	15.32	13.31	251,320	156.16	135.70	94,870	58.95	51.23
M[1] = Meters; SM[2] = Statute miles; NM[3] = Nautical Miles									

Multibeam Echosounder and Sub-bottom Profiler. Along with the air gun operations, two additional acoustical data acquisition systems will be operated from the *R/V Langseth* continuously during the survey. The ocean floor will be mapped with a Kongsberg EM-122 multibeam echosounder (MBES) and a Knudsen 320B sub-bottom profiler (SBP).

The Kongsberg EM-122 MBES operates at 10.5 to 13 kHz (usually 12 kHz) and is hull-mounted on the *R/V Langseth*. The transmitting beam width is 1 or 2-degree fore–aft and 150-degree athwartship. The maximum source level is 242 dB re 1 µPa (rms). Each "ping" consists of eight (in water >1,000 m/3,300 ft deep) or four (<1000 m/3,300 ft) successive fan-shaped transmissions, each ensonifying a sector that extends 1 degree fore–aft. Continuous-wave (CW) pulses increase from 2 to 15 ms long in water depths up to 2,600 m (8,350 ft), and frequency-modulated (FM) chirp pulses up to 100 ms long are used in water >2,600 m (8,350 ft). The successive transmissions span an overall cross-track angular extent of about 150 degree, with 2 ms gaps between the pulses for successive sectors. (See Table 1-3)

The Knudsen 320B SBP is normally operated to provide information about the sedimentary features and the bottom topography that is being mapped simultaneously by the MBES. The beam is transmitted as a 27-degree cone, which is directed downward by a 3.5-kHz transducer in the hull of the *R/V Langseth*. The maximum output is 1,000 watts (204 dB), but in practice, the output varies with water depth. The pulse interval is 1 sec, but a common mode of operation is to broadcast five pulses at 1-sec intervals followed by a 5-sec pause.

Both the Kongsberg EM-122 MBES and Knudsen 320B SBP are operated continuously during survey operations. Given relatively shallow water depths of the survey area (20 – 300 m), the number of 'pings' or transmissions would be reduced from 8 to 4, and the pulse durations would be reduced from 100 ms to 2-15 ms for the Kongesberg EM-122. Power levels of both instruments would be reduced from maximum levels to account for water depth. Actual operating parameters will be established at the time of the survey. Additional details are provided in Table 1-3.

Table 1-3. *R/V Langseth* Sub-bottom Profiler Specifications

Maximum source output (downward)	204 dB re 1 μPa·m; 800 watts
Dominant frequency components	3.5 kHz
Bandwidth	1.0 kHz with pulse duration 4 ms 0.5 kHz with pulse duration 2 ms 0.25 kHz with pulse duration 1 ms
Nominal beam width	30 degrees
Pulse duration	1, 2, or 4 ms

Gravimeter (BGM-3). The *R/V Langseth* will employ a Bell Aerospace BGM-3 gravimeter system (Figure 1-5) to measure very tiny fractional changes within the Earth's gravity caused by nearby geologic structures, the shape of the Earth, and by temporal tidal variations. The BGM-3 has been specifically designed to make precision measurements in a high motion environment. Precision gravity measurements are attained by the use of the highly accurate Bell Aerospace Model XI inertial grade accelerometer.

Figure 1-5. Bell BMG Marine Gravity Meter

Magnetometer (G-882). The *R/V Langseth* will employ a Bell Aerospace BGM-3 geometer which contains a Model G-882 cesium-vapor marine magnetometer (Figure 1-6). Magnetometers measure the strength and/or direction of a magnetic field, generally in units of nanotesla (nT) in order to detect and map geologic formations. These data would enhance earlier marine magnetic mapping conducted by the USGS (Sliter et al., 2009).

The G-882 is designed for operation from small vessels for shallow water surveys, as well as for the large survey vessels for deep tow applications (4,000 psi rating, telemetry over steel coax available to 10 km). Power may be supplied from a 24 to 30 VDC battery power or a 110/220 VAC power supply. The standard G-882 tow cable includes a Vectran strength member and can be built to up to 700 m (2,297 ft) (no telemetry required). The shipboard end of the tow cable is attached to a junction box or on-board cable. Output data is recorded on a computer with an RS-232 serial port.

Figure 1-6. Geometrics G-882 Magnetometer

1.6.3 Onshore Survey Operations

Onshore, a linear array of Zland nodals (or equivalent Iseis Sigma nodes) will be deployed along a single route on the Morro Strand to record onshore sound transmitted from the offshore air gun surveys. The autonomous, nodal, cable-less recording systems (geophones) (Figure 1-7a) would be deployed by foot into the soil adjacent to existing roads, trails and beaches (Figure 1-7b). Route location is shown in Figure 1-8. Ninety nodes would be placed at 100 m (328 ft.) intervals along the Strand for a total route length of ~ 9 km (5.6 mi). The nodal systems are carried in backpacks and pressed into the ground at each receiver point. Each nodal would be removed following completion of the data collection. PG&E estimates that the onshore receiver activities would be conducted over a 2 to 3-day period, concurrent with the offshore surveys.

 * Includes a 5 inch spike, is 6 inches high, 5 inches in diameter, and weighs 5 lbs.	
Zland Nodal Land Recording System	**Iseis Sigma Nodal Land Recording System**

Figure 1-7a. Example of Autonomous Wireless Recording Systems

Figure 1-7b. Typical Wireless Iseis Sigma Nodal Land Recording System Installation
(Battery Pack is located on the left and Recording System on Right)

1.7 PROJECT PERSONNEL AND EQUIPMENT

1.7.1 Equipment Requirements

The following vessels and equipment are being evaluated for use in the proposed offshore survey.

- R/V *Marcus G. Langseth*
  - Two air gun arrays;
  - Four hydrophone streamers;
  - Multi Beam Echo Sounder and Sub Bottom Profiler; gravity and magnetic sensors.
- Chase boat – *R/V Nushagak Spirit* or equivalent
- Support vessel – *M/V Enterprise* or equivalent
- *Support vessel - M/V Michael Uhl*

The following is a preliminary estimate of anticipated vehicle and equipment needs for the proposed onshore geophone placement.

- 1 to 2 equipment van/truck for equipment transport and data recording/processing.

1.7.2 Personnel Requirements

It is estimated that 77 personnel would be required for the proposed offshore survey program. Additional project-related personnel may also participate. The 89 personnel breakdown is as follows:

- *R/V Marcus G. Langseth* crew: 55 (Based on Coast Guard registration)
- *R/V Nushagak Spirit* 6
- *M/V Enterprise* 6
- *M/V Michael Uhl* crew: 5
- Administrative/computer support: 5

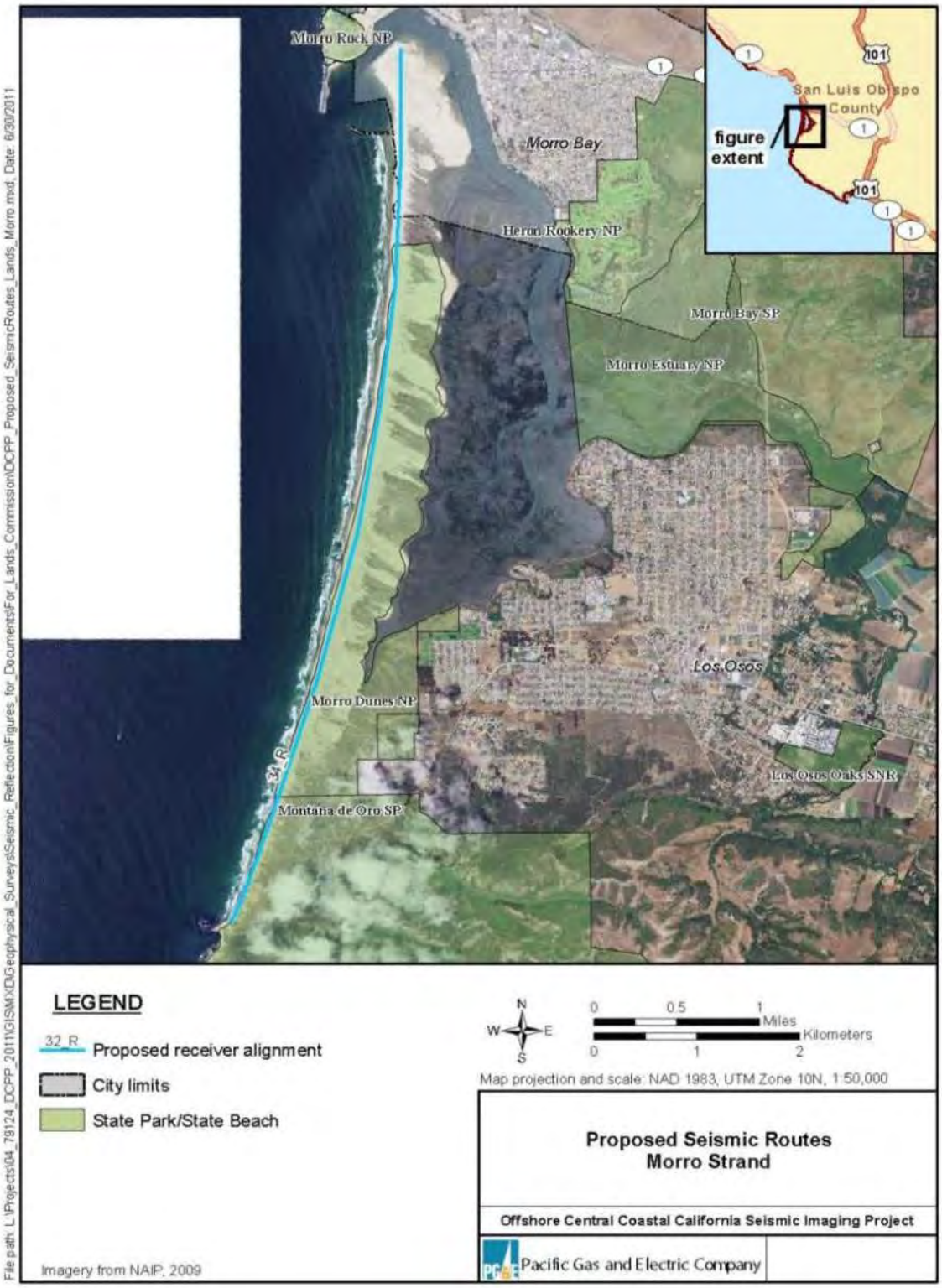


Figure 1-8. Proposed Onshore Seismic Lines

Onshore survey operations are expected to require approximately 6 crew members. In addition, biological and cultural resource monitors would accompany each team in sensitive resource areas. These teams would operate at intervals of 0.8 to 4.8 km (0.5 to 3 mi) throughout the proposed Project area.

1.8 2012 PROJECT SCHEDULE

The proposed activities, including mobilization and demobilization, are expected to take 32.25 operational days to complete, assuming 24/7 operations. This estimate includes time for instrument deployment, profiling, instrument recovery, and demobilization. Mobilization operations during 2012 work window will be initiated no earlier than November 15 and completed no later than December 31, 2012.

Below is an estimated schedule for the Project:

- Mobilization to Project Site - 6 days
- Offshore Equipment Deployment - 3 days
- Pre-activity marine mammal surveys - 5 days (concurrent to equipment mobilization and deployment)
- Onshore geophone deployment – 2 - 3 days (concurrent with offshore deployment activities)
- Equipment Calibration and Sound Check - 5 days
- Seismic Survey
  - Survey Box 4 (Survey area within Estero Bay) - 9.25 days
- Streamer and air gun preventative maintenance - 1 days
- Additional shutdowns (marine mammal presence, crew changes, and unanticipated weather delays) - 2 days
- Demobilization - 6 days

TOTAL: 32.25 days (for 24/7 operation). Note that the total of 32.25 days is based on adding the above non-concurrent tasks.

Placement of the onshore receiver lines would be completed prior to the start of offshore survey activities and would remain in place until the offshore activities can be completed.

1.9 ENVIRONMENTAL COMPLIANCE INSPECTION AND MITIGATION MONITORING

During marine survey operations, key concerns would be the potential impacts to marine wildlife due to exposure to high sound levels associated with the use of the air guns or from direct collisions with the survey vessels. The proposed marine seismic survey activities have the potential to disturb or displace small numbers of marine mammals. These potential effects will not exceed what is defined in the 1994 amendments to the Marine Mammal Protection Act (MMPA) as “Level B” harassment (behavioral disturbance). The mitigation measures to be implemented during this survey are based on Level B harassment criteria using the sound level of 160 dB re 1 µPa (rms), and will, as such, minimize any potential risk of injury, such as damage to the auditory organs. No take by injury or death is likely given the nature of the activities and proposed monitoring and mitigation measures.

In addition, PG&E would implement a Marine Wildlife Contingency Plan (MWCP) which includes measures designed to reduce the potential impacts on marine wildlife, particularly marine mammals, from the proposed operations. This program would be implemented in compliance with measures developed in consultation with NMFS/USFWS and would be based on anticipated exclusion and safety zones derived from modeling of the selected energy source levels. These exclusion and safety zones would be reviewed in context with Incidental Harassment Authorization (IHA) to be conducted by NMFS/USFWS as part of the Project review under the Federal Endangered Species Act and MMPA.

1.9.1 High Energy Seismic Survey Impact Reduction Measures

PG&E is utilizing acoustic models to predict sound levels associated with the air gun array, and this information was used to establish a safety zone and exclusion zone for marine mammals and turtles equating to the distances to the 160 to 180 dB re 1 μPa, respectively. The MWCP that PG&E plans to implement includes these zones to ensure protection of potential effected species. Measures that are also included in the plan are:

- NMFS in cooperation with PG&E will conduct an aerial survey approximately 5 days prior to seismic survey to obtain pre-survey information on the numbers and distribution of marine mammals in the seismic survey area. Additionally aerial surveys will be conducted during active air gun survey operations.
- NMFS-certified protected species observers (PSO) would be stationed on primary survey vessel, on the scout vessel, and on the aircraft (if necessary).
- A scout vessel would be deployed with PSO's to monitor marine wildlife within the survey exclusion and safety zone.
- If marine mammals or other sensitive wildlife are observed within or around the exclusion zone, avoidance measures will be taken including decreasing speed of vessel and a power down or shut down if necessary.
- Use of power up, ramp up, and shutdown procedures would be observed for air gun operations.
- Mitigation air gun would be used during survey turns outside of the 3D survey area as well as during shut down or standby periods.
- Passive Acoustic Monitoring (PAM) will be available to supplement visual monitoring in conditions of poor visibility or low lighting where it doesn't interfere with survey operations.
- If nighttime survey operations are located within the 40 m (131 ft) depth contour, PSO's will visually monitor the area forward the vessel with the aid of infrared goggles/binoculars and the forward looking infrared system available on the R/V Langseth. Mitigation measures, such as avoidance, power down, and/or shut down, would be implemented, if a sea otter is observed within the vessels' path.

In addition, the proposed survey timing (November 1 through December 31) has been developed in consideration of the generally lower presences of migrating and summer season whales in the Project area. PG&E proposes that the surveys are conducted on a 24/7 schedule to reduce overall length of operations thereby lessening impacts to commercial and recreational fisheries.

1.9.2 Onshore Geophysical Survey Impact Reduction Measures

PG&E proposes the following measures to reduce impacts on sensitive wildlife during the onshore survey operations. A Worker Environmental Awareness Training Program (WEAP) would be prepared and presented to all personnel at the beginning of the project. This program was designed to discuss sensitive species and habitats, and why it is important to avoid disturbing them during project activities. A qualified biologist would perform pre-activity surveys along with daily monitoring to document sensitive species and compliance with avoidance measures. Seismic surveys would be designed to avoid California Department of Fish and Game (CDFG) sensitive species and the following federally listed species:

- Morro Bay kangaroo rat
- Morro shoulderband snail
- Western snowy plover
- California least tern
- California clapper rail

1.10 Comprehensive Monitoring Program

In addition to those mitigation and monitoring programs developed by PG&E in support of the seismic survey project implementation, PG&E has agreed to participate in a Comprehensive Monitoring Program. This program has been developed in consultation with numerous resource agencies and research groups including NMFS, USFWS, CDFD, The Nature Conservancy, Ocean Science Trust, Cal Poly San Luis Obispo, and Moss Landing Marine Laboratories. These programs are summarized below.

- **Harbor Porpoise Monitoring Program**. PG&E has agreed to fund a Harbor Porpoise Monitoring Program that will be conducted by the NMFS. The program involves a direct collaboration between NMFS, U.S. Geological Survey (USGS), Brandon Southall (SEA, Inc.), and possibly others. Monitoring would involve a 3-pronged approach to collect data before, during, and after the seismic surveys. The program includes the use of PODs and high-frequency acoustic recording packages (HARPS).

- **Sea Otter Monitoring Program**. PG&E has agreed to fund a Sea Otter Monitoring Program that will be conducted by the USFWS, California Department of Fish and Game Marine Wildlife Veterinary Care and Research Center (MWVCRC), the Monterey Bay Aquarium Sea Otter Research and Conservation Department, and University of California and Santa Cruz and Davis. The monitoring program will provide a real-time monitoring infrastructure with which to detect and measure levels of harassment caused by the surveys, as required by the USFWS, while at the same time providing useful information on behavioral response thresholds as a function of sound exposure for sea otters. This program was initiated on October 1, 2012.

- **Stranding Response Plan**. PG&E has agreed to support a Stranding Response Plan developed by the NMFS, USFWS and CDFG. This plan will be implemented in close coordination with the Harbor Porpoise and Sea Otter Monitoring Programs.

Data from the program will also be used in the evaluation of impacts under the Adaptive Management Program.

- **Aerial Survey Program**. NMFS will conduct aerial surveys in conjunction with the proposed seismic survey operations as outlined in the HESS Guidelines and in accordance with the requirements established by the CSLC FEIR mitigation measures (CSLC, 2012). In addition to the these aerial surveys, NMFS/USFWS will be conducting low level aerial surveys designed to monitor southern sea otter and Morro Bay harbor porpoise movements in response to the seismic survey operations. Baseline aerial surveys will commence on October 1, 2012.
- **Adaptive Management Program**. Data generated during pre-activities surveys and ongoing operational monitoring activities will actively be used during the proposed seismic survey to adjust or redirect operations should significant adverse impacts be observed to marine resources in the project area. This program will rely on data generated during the Harbor Porpoise and Sea Otter Monitoring Programs along with vessel based PSO observations.
- **Study of the Effects of the Seismic Survey on Fishes**. PG&E has agreed to fund a two-component study to examine the short- and long-term effects of the seismic survey on fish abundance (and invertebrates). Components of the study include: (1) Remote Operated Vehicle (ROV) surveys to assess the abundance of common rockfishes and other demersal fish and invertebrate species in sites before, during, and after the seismic survey; and (2) funding the California Collaborative Fisheries Research Program (CCFRP), which is an existing program between the fishing communities of Half Moon Bay, Moss Landing/Monterey, Morro Bay, Port San Luis and the academic institutions of Moss Landing Marine Labs and Center for Coastal Marine Sciences at Cal Poly, San Luis Obispo to study the long-term effects of the HESS on fish abundance in shallower waters. The CCFRP involves both Catch per Unit Effort (CPUE) and Commercial Trap surveys.

By Electronic Mail

September 21, 2012

Chair Mary Shallenberger and
Members of the California Coastal Commission
45 Fremont Street, Suite 2000
San Francisco, CA 94105-2219

E-mail: cteufel@coastal.ca.gov; mdelaplaine@coastal.ca.gov

Re: *Coastal Development Permit and Federal Consistency Certification for the Central Coastal California Seismic Imaging Project*

Dear Chair Shallenberger and Members of the Commission:

On behalf of the Natural Resources Defense Council (NRDC), Ocean Conservancy and our over one million members and activists—more than 250,000 of whom reside in California— we are writing to submit updated comments on PG&E's Central Coastal California Seismic Imaging Project (CCCSIP or "seismic survey"), scheduled for your October 2012 meeting.

In the wake of the emergency at the Fukushima Daiichi Nuclear Power Station last year, we understand the importance of reassessing the earthquake risk at the Diablo Canyon nuclear reactor in San Luis Obispo County with improved data where possible, and we fully support the goal of ensuring the plant's safety. But the proposed seismic survey will have highly significant, unavoidable impacts on endangered and vulnerable marine mammals and on recently established marine protected areas, meant to provide lasting protections for California's unique marine ecosystems, habitats, and species. Among the species benefitting from this protection are depleted central coast rockfish, which are beginning a lengthy recovery.[1] The seismic survey will also affect a wide range of other species and the human communities that depend on ocean ecosystems. To our knowledge, a high-energy seismic survey of the proposed duration and extent has never been conducted in such important near-coastal habitat off California.

The high environmental costs associated with the proposed survey have led us to carefully scrutinize the need for this project, as we worked to make recommendations on how to improve its design. We started with the assumption that the survey would provide necessary information to assess the plant's safety. But after combing through numerous reports and consulting a range of experts, **we have found no conclusive evidence that the information from the seismic survey is either essential for assessing earthquake risk at the plant or likely to result in improvements in the plant's safety**.

[1] State Lands Commission and ERM-West, 2012. Final Environmental Impact Report (EIR) for the Central Coastal California Seismic Imaging Project.

Of the three top sources of uncertainty regarding earthquake risk to the plant, the proposed survey will only shed light on the least influential for assessing seismic safety—the dip of the Hosgri fault.[2] Meanwhile, many other studies are underway to address the full range of uncertainties. The graph below illustrates that for any reasonable assumption about the Hosgri fault dip, PG&E and other experts find that the magnitude of ground shaking from that fault (colored lines) would fall within what the plant is designed to withstand (taller black line).[3] The seismic survey findings might reveal a larger margin of safety, but are not likely, based on observations of small earthquakes on this fault as well as gravity and magnetic data, to change the fundamental conclusion.

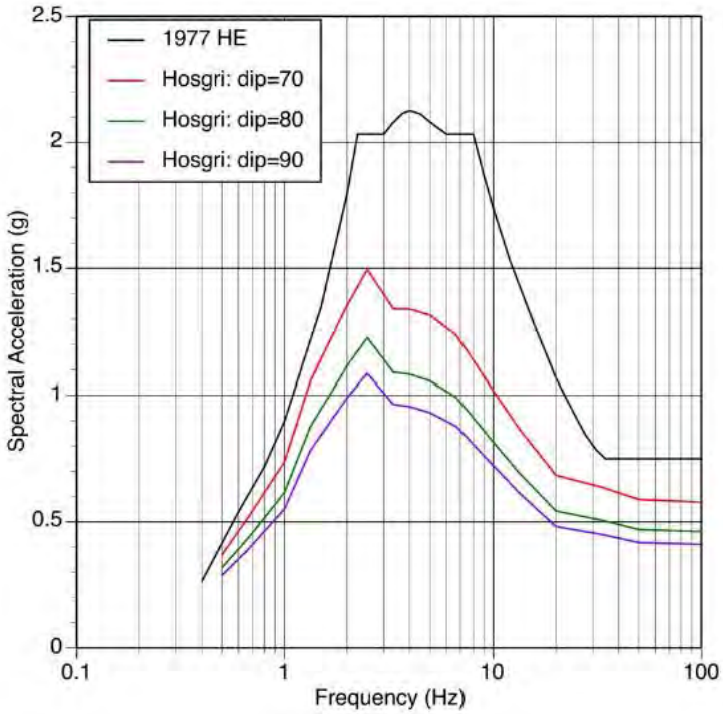


Figure 1. *Hosgri Fault sensitivity to estimates of dip. The black line reflects the level of ground shaking the Diablo Plant is designed to withstand.*[4]

---

[2] Wooddell, Kathryn and Nick Gregor, 2011. SSHAC Workshop Report 0104, Sensitivity. Pp 56-58 of this report, prepared by PG&E, show that the top sources of uncertainty are the Hosgri slip rate (better understood through low energy studies), the Hosgri location and the Hosgri dip. Pp. 90-92 show that uncertainty due to the way the ground shaking is computed have a greater effect on ground shaking estimates than uncertainties in the fault system. So, from PG&E's own study, the most important sources of uncertainty are, in order of importance: (1) how the ground shaking is modeled, (2) the slip rate of the Hosgri fault, and (3) the location and dip of the Hosgri fault. The seismic studies address only point (3). Our Figure 1 shows that for any reasonable dip of the Hosgri fault, the modeled shaking is within the design of the plant (the black line labeled 1977 HE), so point (3) is not of great importance to the safety of the plant.

[3] Wooddell, Kathryn and Nick Gregor, 2011. SSHAC Workshop, General 0104, Sensitivity, p. 7. A similar graph in Fig. 6-19, p. 51 of the Shoreline Fault Zone Report shows that the same conclusion holds true with either of the accepted approaches to computing ground shaking.

[4] PG&E 2012. SSHAC Workshop Reports, 0104, p.7

In our view, the environmental cost of the survey must be weighed against the likely benefit of additional information that it might provide. Given a lack of convincing evidence that the survey is necessary for assessing earthquake risk to the power plant, we view the environmental costs of conducting the survey itself as simply too high to justify a modest predicted information benefit. Approval of the survey would also set a harmful and legally dubious precedent of allowing adverse impacts to the biologically significant habitats and species in California's MPAs in the absence of a compelling public need to do so. **We therefore urge the Coastal Commission to deny the coastal development permit and federal consistency certification for the CCCSIP while a cost/benefit study of the marginal benefits of the additional information is performed, information from other geophysical studies is synthesized, and baseline monitoring is conducted. A decision to permit the project in the future should be based on finding a positive benefit/cost ratio.**

In subsequent sections we demonstrate that the seismic survey would violate Coastal Act Section 30230, does not qualify for a permit "override" under Section 30260, and is not required by regulation or statute. We then summarize conditions we view as essential to minimize harm to the marine environment if the Commission does choose to permit and approve this project.

I. The proposed survey would have significant, unavoidable environmental impacts on marine resources, in violation of Coastal Act Section 30230.

The California Coastal Act states that "[m]arine resources *shall* be maintained, enhanced, and, where feasible, restored. *Special protection shall be given to areas and species of special biological or economic significance*. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain *healthy populations of all species of marine organisms* adequate for long-term commercial, recreational, scientific, and educational purposes." [5] We believe that the CCCSIP would violate section 30230 for three reasons.

<u>First, the CCCSIP would have significant, unavoidable impacts on protected marine mammal species</u>. The CCCSIP FEIR identifies major impacts on four endangered species of marine mammals: blue whales, fin whales, humpback whales, and California sea otters (CCCSIP FEIR). Of greatest concern, however, is the small, discrete population of harbor porpoises that resides in and around Morro Bay. Of all marine mammal species, harbor porpoises are the most acutely sensitive to man-made sound – the ones most vulnerable both to habitat abandonment and to hearing loss, which, given their dependence on sound for most life functions, can destroy their ability to survive and reproduce. Most of the Morro Bay population's limited range, and nearly all of its core habitat, coincides with the CCCSIP, and would be ensonified to levels causing take on most if not every day of the survey, even using NMFS' non-conservative 160 dB threshold (See Figure 2).

The FEIR concludes that permanent hearing loss and other serious injury incurred as a result of the Proposed Project would exceed what the Morro Bay population can annually sustain, and that these injuries are "significant and unavoidable."[6] Yet impacts from behavioral disruption could be even more consequential. Given their extreme aversion to intense sound, it is reasonable to expect that virtually the entire porpoise population will abandon the majority of their habitat – at the height of their breeding season and during the first few months of nursing for mothers and calves – and crowd into sub-optimal areas (FEIR at H-101) unlikely to provide sufficient foraging. Harbor porpoises require

[5] Pub. Res. Code § 30230 (emphases added)
[6] FEIR at 4.4-75, 4.4-79

substantial daily caloric intake to survive and cannot safely go more than a few days without adequate food, which is also vital to their reproduction. As with injury, the FEIR considers behavioral impacts on harbor porpoises to be significant and unavoidable at the population scale. FEIR at 4.4-85, H-101. The critical mitigation measures we recommended in our August 8 letter would substantially reduce but not eliminate the risk of significant, population-level harm.

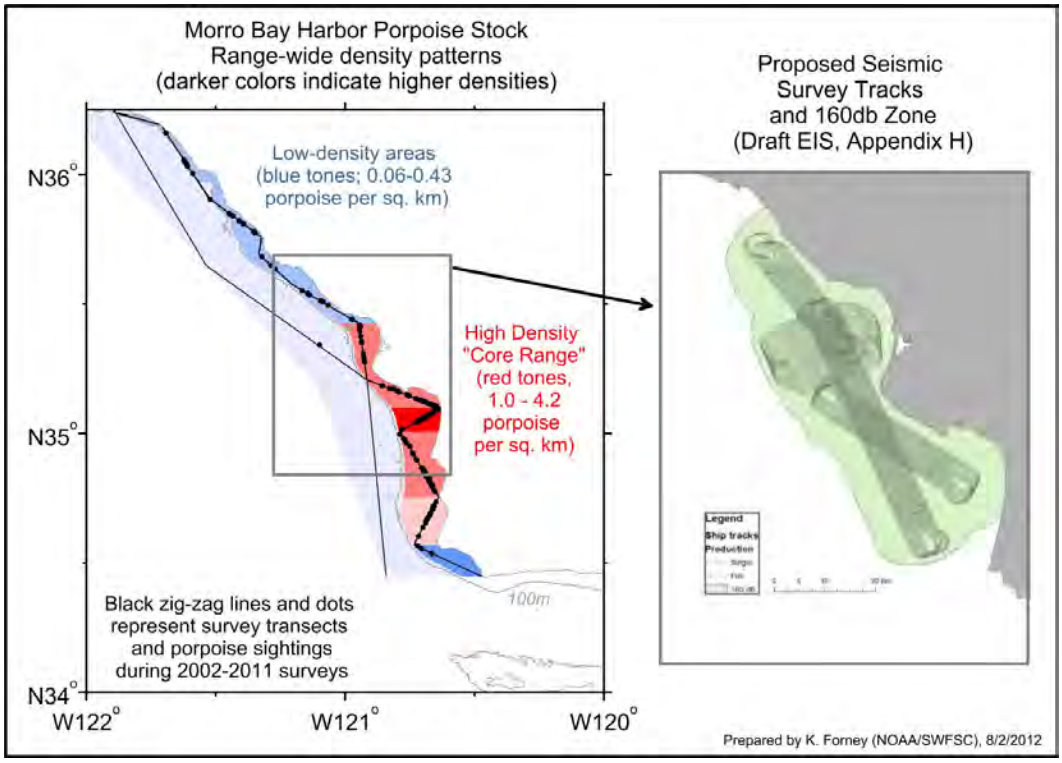


Figure 2. *Map prepared by NMFS' Southwest Science Center showing distribution of core habitat of Morro Bay harbor porpoises (left) and CCCSIP tracklines and 160 dB ensonification zone (right).*

<u>Second, the CCCSIP would very likely have major impacts on fish and other non-mammal species</u>. To our knowledge, a high-energy seismic survey of the proposed duration and extent has never been conducted in such important near-coastal habitat off California. As such, the actual impacts from the proposed project to marine resources in the Project Area are unknown but may be very serious. We are particularly concerned with potential impacts to federally-declared overfished species such as rockfish and to species of high ecological significance such as squid.

The FEIR's conclusion that the impact of the Proposed Project on adult, juvenile, and larval fish and would be "less than significant" is not adequately supported.[7] FEIR at 4.4-72. Potential impacts of noise

[7] FEIR at 4.4-69 through 4.4-73. *See, e.g.*, McCauley, R.D., Fewtrell, J., Duncan, A.J., Jenner, C., Jenner, M.-N., Penrose, J.D., Prince, R.I.T., Adhitya, A., Murdoch, J., and McCabe, K., Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid (2000); McCauley, R., Fewtrell, J., and Popper, A.N., High intensity anthropogenic sound damages fish ears, *Journal of the Acoustical Society of America* 113: 638-642 (2003); Kostyuchenko, L.P., Effect of elastic waves generated in

on commercially harvested fish include reduced reproductive performance, and recent data suggest that loud, low-frequency sound may disrupt chorusing—a behavior essential to breeding— in some commercial species.[8] Furthermore, emerging research found that juvenile Chinook salmon exposed to high-intensity impulsive sound suffered from tissue injuries associated with barotrauma.[9] A 2010 study in the *Journal of Experimental Biology* documented that squid hearing is within the frequency range 30-500 Hz – well within the range of the proposed project's maximum-over-depth broadband (10Hz-2kHz) sound pressure levels and within the frequency band of maximum energy output.[10] Since squid are a critical forage species for many seabirds, marine mammals, and fish, any adverse impacts to squid could also potentially impact their predators and the wider ecosystem.

In addition to physical impacts, airgun surveys are known to significantly affect the distribution of some fish species and dramatically depress catch rates of commercial fish over very large areas of ocean, far beyond the boundaries of the surveys.[11] Vertical and horizontal displacement in the water column has the potential to influence foraging and reproductive success and result in much broader impacts to fish populations than are acknowledged in the FEIR.

Third, the seismic survey will undermine the ecosystem protection and restoration goals of newly established marine protected areas (MPAs) in San Luis Obispo County, including the State Marine Reserve and State Marine Conservation Area at Point Buchon, as the FEIR expressly acknowledges.[12] Although designated under separate statute, the Point Buchon MPAs are designed to address substantially similar ecosystem and species protection goals as Coastal Act Section 30230. The goals of the Marine Life Protection Act include:

(1) To protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems;
(2) To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted; and

---

marine seismic prospecting on fish eggs in the Black Sea, *Hydrobiology Journal* 9:45-48 (1973); Booman, C., Dalen, J., Leivestad, H., Levsen, A., and van der Meeren, T., The effects of airguns on eggs, larvae and fry, *Fiskens Og Havet* 3 (1996).

[8] Clark, C.W., pers. comm. with M. Jasny, NRDC (Apr. 2010) (unpublished data on disruption of drum fish chorusing by low-frequency shipping noise).

[9] Halvorsen, M.B, Casper, B.M, Woodley, Carlson, T.J., Popper, A.N., Threshold for Onset of Injury in Chinook Salmon from Exposure to Pile Driving Sounds, *PLoS ONE*, Volume 7, Issue 6 (June 2012).

[10] Mooney, T.A., Hanlon, R.T. Christensen-Dalsgaard, J., Madsen, P.T., Ketten, D.R., and Nachtigall, P.E., Sound detection by the longfin squid (*Loligo pealeii*) studied with auditory evoked potentials: sensitivity to low-frequency particle motion and not pressure, *J Exp. Biol.* 213: 3748-3759 (2010).

[11] Engås, A., Løkkeborg, S., Ona, E., and Soldal, A.V., Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*), *Canadian Journal of Fisheries and Aquatic Sciences* 53: 2238-2249 (1996); *see also* Løkkeborg, S., Ona, E., Vold, A., Pena, H., Salthaug, A., Totland, B., Øvredal, J.T., Dalen, J. and Handegard, N.O., Effects of seismic surveys on fish distribution and catch rates of gillnets and longlines in Vesterålen in summer 2009 (2010) (Institute of Marine Research Report for Norwegian Petroleum Directorate); Slotte, A., Hansen, K., Dalen, J., and Ona, E., Acoustic mapping of pelagic fish distribution and abundance in relation to a seismic shooting area off the Norwegian west coast, *Fisheries Research* 67:143-150 (2004).

[12] CCCSIP FEIR at 4.10-22.

(4) To protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value.[13]

Similarly, as stated by the Marine Managed Areas Improvement Act, the purposes of state marine reserves are to:

(1) Protect or restore rare, threatened, or endangered native plants, animals, or habitats in marine areas.
(2) Protect or restore outstanding, representative, or imperiled marine species, communities, habitats, and ecosystems.
(3) Protect or restore diverse marine gene pools.
(4) Contribute to the understanding and management of marine resources and ecosystems by providing the opportunity for scientific research in outstanding, representative, or imperiled marine habitats or ecosystems.[14]

Marine Life Protection Act goal (2), in particular, mirrors Coastal Act language regarding sustaining the biological productivity of coastal waters, as well-designed marine protected areas increase productivity relative to fished areas by providing a haven for large prolific fish. Indeed, the Point Buchon MPAs are known to provide refuge for economically valuable but depleted rockfish, aiding in their recovery by protecting "big old fecund female fish." Similarly, MLPA goal (4) mirrors Coastal Act language regarding areas of special biological significance; and goal (1) mirrors Coastal Act language regarding healthy populations of all species.

Further exegesis should not be needed to illustrate that the protections afforded marine ecosystems and species in the Point Buchon MPAs are not only consistent with the policies of Section 30230, but should draw special attention consistent with the Commission's charge to protect "healthy populations of all species" and to provide "special protection to areas of special biological or economic significance." Certainly, an activity like the CCCSIP, which so clearly undermines the purpose of the MPAs, should be highly suspect under the Coastal Act.

The FEIR correctly states that even with proposed mitigation and monitoring measures, conflicts with Section 30230 "remain significant and unavoidable."

II. The seismic survey fails to meet the criteria for an "override" under Coastal Act Section 30260

Section 30260 states that "where new or expanded coastal-dependent industrial facilities cannot feasibly be accommodated consistent with other policies of the act, they may nonetheless be permitted in accordance with this section" if they meet certain criteria. If the proposed survey is properly considered a "facility"—which is not at all clear in this case[15]—the Commission must find, initially, that

[13] Fish and Game Code section 2853(b).
[14] Public Resources Code section 36700(a). The core purposes of state marine conservation areas are identical, with the addition of language regarding the need to "provide for sustainable living marine harvest" and language regarding the protection of geological resources. *Id*. At section 36700(b).
[15] The Coastal Act provides no indication that an activity such as the seismic testing proposed here should be considered a qualifying "facility" under Section 30260. To the contrary, the statutory language suggests that an "override" is not available here. The Coastal Act does not provide a general definition of "facility," but by way of

the project cannot reasonably be accommodated consistent with the other policies of the Coastal Act. It must then go on to show that all three of the conditions below are met:

(1) alternative locations are infeasible or more environmentally damaging;
(2) to do otherwise would adversely affect the public welfare; *and*
(3) adverse environmental effects are mitigated to the maximum extent feasible.

The second condition—whether "to do otherwise would adversely affect the public welfare"— is the key test here. The Commission must ask whether the public welfare would be adversely affected if the survey did not proceed. In asking this question, it is appropriate for the Commission to weigh the significant ecological harm that the survey will likely cause against the public need for the survey to occur. For purposes of applying Section 30260, "a determination of what will adversely affect the public welfare requires consideration of the preservation and protection of the state's natural resources and the ecological balance of the coastal zone *as well as* the need for a particular type of coastal-dependent development." *Gherini v. California Coastal Commission*, 204 Cal. App. 3d 699 (1988) (emphasis added). We believe that the purported benefits of the survey will not justify the expected harm, for the following reasons.

First, as PG&E itself has publicly stated, the survey is likely not essential for resolving key questions regarding the safety and relicensing of Diablo Canyon. None of the proposed survey zones actually cover the Shoreline fault, the discovery of which is offered as the rationale for the survey. Moreover, in the environmental document that PG&E submitted with its license renewal application to the Nuclear Regulatory Commission, PG&E stated that "[a]lthough the presence of the potential Shoreline Fault offshore of DCPP is new information, based on the PG&E and NRC assessments of the potential Shoreline Fault, it is not significant information since the design and licensing basis evaluations of the DCPP structures, systems, and components are not expected to be adversely affected."[16]

Similarly, in a 2010 report to the NRC, PG&E documented extensive land-based and low-energy seismic data collection that it had already conducted on the Shoreline fault. PG&E stated, on the basis of the new information, that discovery of the Shoreline fault "does not affect the seismic safety of DCPP."[17] And in multiple 2010 communications with the CPUC, PG&E argued that it already has sufficient information on the Shoreline fault to assess nuclear safety, and that the NRC "independently confirmed" PG&E's assessment that Diablo Canyon is seismically safe.[18] The Diablo Canyon Independent Safety Committee of the NRC stated, in a May 2012 annual report, "The preliminary results of the PG&E

---

illustration, Section 30107 defines an "energy facility" narrowly with reference to physical structures with particular functions, such as "a public or private processing, producing, generating, storing, transmitting, or recovering facility for electricity, natural gas, petroleum, coal, or other source of energy." By contrast, Section 30106 of the Coastal Act defines "development" expansively to include many types of activities, such as construction, dredging, and waste disposal. The use of the narrower term "facility," rather than the broader term "development," in Section 30260 indicates that the provision is not meant to be used for activities such as seismic testing.

[16] PG&E, undated. Diablo Canyon Power Plant License Renewal Application, Appendix E. Environmental Report, http://www.nrc.gov/reactors/operating/licensing/renewal/applications/diablo-canyon/dcpp-er.pdf. At Chapter 5-4

[17] PG&E, 2010. Progress Report on the Analysis of the Shoreline Fault Zone, Central Coastal California, Report to the U.S. Nuclear Regulatory Commission.

[18] PG&E, 2010. "Pacific Gas and Electric Company Response to Requests to Suspend Diablo Canyon License Renewal Proceedings," Ex Parte Communications filed with the CPUC.

analysis of the Shoreline Fault rupture showed that the DCPP seismic design basis remained valid for any of three possible scenarios, either (1) as a single segment or (2) as all three segments together, or (3) as all three segments combined with a Hosgri rupture."[19]

Second, the survey is not expected to help resolve the most important geological uncertainties. The highest priority uncertainty the survey *might* reduce involves the dip of the Hosgri fault.[20] But existing analysis shows that even with the current uncertainties about that dip, the ground shaking that fault could produce would be well within levels the plant is designed to withstand.[21] The survey will not resolve the debate about whether an earthquake on the Hosgri fault could sidetrack into a branch fault like the Shoreline fault. That question is likely to be answered either by more sophisticated modeling or a quake on an analogous fault system. Nor will it resolve the two biggest sources of uncertainty about earthquake risk at the plant: the uncertainty related to the choice of models for computing ground shaking, or the slip rate of the Hosgri fault, which low energy studies are likely to inform. Given that, as noted above (see Fig. 1), the modeled shaking is within the design of the plant (the black line labeled 1977 HE) for any reasonable dip of the Hosgri fault – even assuming a highly conservative scenario – acquiring additional information on the Hosgri dip is not of great importance to the safety of the plant.

Third, the California Energy Commission's recommendations, per its AB 1632 report (2008), stated only that additional testing might enable better assessments of safety at DCPP. CEC did not make a case that high-energy testing is absolutely necessary to address the risks. Importantly, it does not appear that CEC or any other body undertook a comprehensive risk or cost/benefit analysis to determine whether, for each uncertainty the seismic testing aims to constrain, the marginal benefits of that additional information are worth the expected adverse costs in the form of impacts on local communities, protected species and MPAs, as well as financial costs. We believe the public and the ratepayers deserve to see such an analysis before decisions about permitting are made.

It is conceivable that the proposed survey would maintain or enhance the public good if it could generate information that enabled a meaningful decision about whether to relicense Diablo Canyon as-is, improve upon the existing seismic safety measures, or close the Diablo Canyon Power Plant altogether. Yet it is clear today that the survey is not expected to help resolve the most important geological questions at issue, and even if it did, *it is not likely to change the calculation of whether the DCPP is safe and should be relicensed*. For these reasons, the survey fails to meet the criteria for permitting under Section 30260, and should be denied.

III. There is no controlling legislative or regulatory mandate for this survey

State legislation and directives from the CEC and CPUC have been invoked to justify the CCCSIP. But none of these sources of authority mandates the completion of the CCCSIP at any cost, none requires

[19] Diablo Canyon Independent Safety Committee Twenty-first Annual Report on the Safety of Diablo Canyon Nuclear Power Plant Operations, July 1, 2010--June 30-2011, p. 10.

[20] In its AB 1632 report, the CEC recommended high-energy seismic testing on the rationale that it "*might* alter fault parameters that are used in existing seismic estimates" and "*may* be significant for engineering vulnerability assessments." CEC, 2008. An Assessment of California's Nuclear Power Plants: AB 1632 Report p. 3-7 (emphasis added).

[21] PG&E, 2011. Report on the Analysis of the Shoreline Fault Zone, Central Coast California p. 6-51.

seismic testing on any particular timeline, and none has considered whether CCCSIP's environmental effects are worth its benefits.

Notably, the Blakeslee legislation from 2006 (AB 1632) did not require new high-intensity geophysical studies. The Blakeslee legislation amended Section 25303 of the Public Resources Code, which governs the CEC's energy assessment and planning activities. It required that the CEC compile and assess *existing* scientific studies to determine the potential vulnerability to a major disruption, due to aging or from a major seismic event, of the state's two nuclear facilities. The Blakeslee legislation did not provide CEC with authority to require new seismic studies or to base any regulatory decisions on the availability of such studies. Nor did it impose regulatory requirements on PG&E itself.

The CEC and CPUC have taken steps to implement the Blakeslee legislation, but have done so in service of their missions to provide for grid reliability and protect the interests of ratepayers. In 2008, the CEC published an assessment that concluded: "PG&E should use three-dimensional seismic reflection mapping and other advanced techniques to explore fault zones near Diablo Canyon."[22] The report goes on to say that given the potential for a long shutdown after a major seismic event, the CEC and other state agencies should evaluate whether such studies should be required as part of the Diablo Canyon licensee renewal feasibility study for the CPUC. In its 2007 General Rate Case Decision for Diablo Canyon – published prior to the completion of the CEC assessment – the CPUC directed PG&E to incorporate the AB 1632 recommendations into a license renewal feasibility study that would inform a decision regarding whether license renewal is cost-effective and in the best interests of the ratepayers. A 2010 CEC letter describing subsequent communications between CEC, CPUC, and PG&E further clarifies that the energy agencies' interests in CCCSIP are predominantly driven by grid reliability and ratepayer protection concerns.[23]

Importantly, the Nuclear Regulatory Commission, which has sole authority to assess the radiological safety of Diablo Canyon, does not appear to have required the CCCSIP as part of the relicensing process. Nor does the NRC appear to have required any new surveys on a particular timeline. For instance, in its June 7, 2011 order delaying the completion of the Diablo Canyon relicensing process, the NRC states that PG&E – not the NRC – decided it would be "prudent" to complete new seismic surveys prior to finalizing its relicensing application.[24] The order states that "[i]n short, PG&E asked NRC to defer issuance of the renewed DNCPP license" until the surveys had been completed. The NRC acceded to this request but noted that waiting for completion of the surveys would "significantly delay" the already-scheduled relicensing process. The NRC concluded by directing PG&E to provide monthly progress reports until NRC staff could reestablish a schedule. These are not the words of a regulatory agency that urgently requires critical new information.

---

[22] CEC, 2008. An Assessment of California's Nuclear Power Plants: AB 1632 Report, p. 6. From State Lands Commission staff review for Item 104, 8/14/12, p.3 [add url]

[23] CEC, Letter re: PG&E's Applications to Recover Costs for Diablo Canyon Seismic Studies and Obtain State and Federal Approvals Related to Relicensing Diablo Canyon, Ex Parte Communication with the CPUC (June 3, 2010).

[24] Nuclear Regulatory Commission, Notice of 52-Month Delay and Order Requiring Status Reports (June 7, 2011).

In a March 12, 2012 order issued following the Fukushima disaster, the NRC requires risk evaluation of seismic hazard and sets the timeline for facility owners to submit data for that evaluation, but does not require new seismic surveys. Additionally, the order allows companies to request changes in the NRC's generic timeline for submission of data. Indeed, PG&E has already notified the NRC, and the NRC has acknowledged, that it may advance an alternate timeline for submission.[25]

In sum, it is our understanding that there is no controlling legislative mandate for the CCCSIP, that the decisions of the CEC and CPUC have been limited to grid reliability and ratepayer considerations, and that the Nuclear Regulatory Commission does not see this project as necessary for making a relicensing decision.

IV. The Commission should object to the federal consistency certification for the CCCSIP.

Because the CCCSIP does not comply with Sections 30230 and 30260, the Coastal Commission must also object to the project's federal consistency certification, as required by the California Coastal Act and the federal Coastal Zone Management Act (CZMA). Because the CCCSIP will have reasonably foreseeable effects on resources and human uses in California's coastal zone, the CZMA requires PG&E to certify that the CCCSIP is fully consistent with the enforceable policies of management programs unless full consistency is prohibited by existing law applicable to the applicant agency.[26] Chapter 3 of the Coastal Act, which includes Sections 30230 and 30260, contains the state's enforceable policies.[27] PG&E has the burden to demonstrate that the CCCSIP would be consistent with Chapter 3 if it were allowed to proceed, and PG&E has not met that burden;[28] nor has it demonstrated that existing law applicable to the applicant National Science Foundation precludes full consistency. Because PG&E has failed in this regard, the Commission must lodge a proper objection.[29]

V. Recommendation: for all these reasons, the Coastal Commission should deny the coastal development permit and federal consistency certification for the CCCSIP while a cost/benefit study of the marginal benefits of the additional information is performed, information from other geophysical studies is synthesized, and baseline monitoring is conducted. A decision to permit the project in the future should be based on finding a positive benefit/cost ratio.

We believe PG&E has been acting responsibly in responding to legislative and information-gathering directives by pursuing plans for the CCCSIP. However, neither the legislature nor any energy agencies conducted an environmental review to identify the significant harms that the CCCSIP will cause, and none weighed the project's marginal benefits against its expected environmental and social costs. Now that the requisite information has become available, we are convinced not only that the project's

---

[25] Nuclear Regulatory Commission, March 12, 2012l
Request for Information Pursuant to Title 10
[26] 16 U.S.C. § 1456(c)(3)(A); 15 C.F.R. §§ 930.51, 930.52, 930.57.
[27] Public Resources Code §§ 30008, 30330.
[28] 15 C.F.R. § 930.58(a)(3).
[29] 15 C.F.R. § 930.63; Public Resources Code § 30330.

tremendous costs outweigh its benefits, but that the project is inconsistent with Section 30230 and 30260 of the Coastal Act. For these reasons, we urge Coastal Commission to deny the coastal development permit for the CCCSIP while a cost/benefit study is performed and information from other geophysical studies and baseline biological studies can be synthesized.

VI. Recommendation: If the Coastal Commission chooses to grant a permit, we urge you to adopt the following measures to reduce and monitor its impacts.

A. As a first choice, we recommend delaying the seismic work until 2013 and conditioning the permit with requirements for: baseline monitoring; a cost/benefit analysis focused on the marginal benefit to be gained from the seismic activity, relative to its environmental and other costs, made available to the public and decision makers; and a synthesis of geophysical information from other studies, such as land-based and low-energy surveys, to help inform the decision about whether seismic surveys are necessary.

Seismic work that goes forward in 2013 should be designed consistent with the provisions in Section B below.

Examples of baseline monitoring that should be required for assessing marine mammal impacts include:

1. Fine-scale aerial surveys and passive acoustic monitoring focused on harbor porpoise and baleen whale distribution, using the same aerial and passive acoustic resources (NMFS overflights, PCODs, HARPs) proposed for the current year's survey. While a full year of data would be optimal, the effort should minimally sample the months of November and December (the seismic survey window) and next August through October (leading up to the survey).
2. Photogrammetry to refine our understanding of the peak calving and weaning seasons of harbor porpoises. Photogrammetry, which has recently been completed for common dolphins off the California coast,[30] involves acquiring high-resolution photos that can be analyzed for calf size and estimated age.

B. Alternatively, if the Commission decides to grant a permit for activities that start this year, we recommend minimizing impacts on vulnerable species through the following steps:

1. Spread the seismic survey over two years and strictly limit the number of seismic days in any one year to avoid lengthy exposure of Morro Bay harbor porpoises to air gun blasts;
2. Authorize only the Zone 4 survey in year one, so that data on impacts can inform decisions about the more sensitive Zone 2 in year two;
3. Establish triggers for suspending the project if certain levels of impacts to endangered, protected, or vulnerable marine mammals are exceeded. Thresholds should be designed to apply in real time and also to serve as standards for a review of biological impacts at the end of

[30] Chivers, S.J., Perryman, W.L., Lynn, M.S., Danil, K., Berman, M., and Dines, J.P., 2011. Aerial photographs reveal unique breeding characteristics for *Delphinis capensis* and *D. delphis* off southern California, USA and Baja California, Mexico. Available at http://swfsc.noaa.gov/uploadedFiles/Chivers_2011MMCAbstract.pdf?n=9794.

the year one survey. To this end, the Commission should review the triggers currently in preparation by NMFS;

4. Require, upon completion of the year one survey, an independent review of biological and geophysical monitoring data in order to inform year two. Review of the biological data before the second year could help determine the level of impacts and inform adjustments to the survey in year two to reduce those impacts. Authorization of the survey in Zone 2, which would occur within more sensitive nearshore waters, should be denied in year two if analysis from year one indicates that certain levels of impacts to marine mammals are exceeded.

5. Review of the geophysical results should examine whether the data from year one are of sufficient quality and are critically needed to resolve key uncertainties in the assessment of earthquake risk. We note that a review of geophysical data by the IPRP is planned, but the CCC or the CPUC—the sponsoring agency for the IPRP—would need to expand the scope of the IRPR review and establish a schedule for timely completion to be useful for this purpose. If data collected in year one do not prove to be sufficiently useful and necessary to resolve key uncertainties in the assessment of earthquake risk, the year two survey should not be performed.

6. Eliminate Zone 1 from the project footprint. Because Zone 1 is close to shore where the damage to harbor porpoises is likely to be particularly high, and because it does not actually cover the Shoreline fault so is unlikely to yield valuable geophysical data, it should not be authorized at this time.

7. Require full mitigation for unavoidable significant impacts to marine protected areas.

8. Require the development and implementation of a comprehensive monitoring program to assess the impacts of the seismic survey with an emphasis on marine protected areas and marine mammals, including, in addition to PG&E's proposed measures:

   a. Scuba surveys to monitor fish and other marine life in shallow water inside and outside the MPAs in addition to the elements approved by State Lands Commission; and

   b. HARPS—high-frequency acoustic recording packages—which provide information on baleen whale distribution, in addition to NMFS' requirements. While a full year of data would be optimal, the effort should minimally sample the months of November and December (the seismic survey window) and next August through October (leading up to the survey).

We appreciate the opportunity to discuss these issues with you and your staff. For further discussion, please do not hesitate to contact Michael Jasny at 310-560-5536, mjasny@nrdc.org or Karen Garrison, 415 875 6160, kgarrison@nrdc.org.

Very truly yours,

Michael Jasny
Senior Policy Analyst
NRDC

Kaitilin Gaffney
Pacific Program Director
Ocean Conservancy

Karen Garrison
Co-Director, Oceans Program
NRDC

NATURAL RESOURCES DEFENSE COUNCIL

Via Electronic Mail

October 15, 2012

P. Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910
ITP.Goldstein@noaa.gov

Re: *Proposed IHA for Central Coastal California Seismic Imaging Project*

Dear Mr. Payne:

On behalf of the Natural Resources Defense Council ("NRDC") and Ocean Conservancy, and our more than one million members and activists, we are writing to urge modifications to the proposed incidental harassment authorization ("IHA") for the Central Coastal California Seismic Imaging Project, conducted by Lamont-Doherty Earth Observatory and Pacific Gas & Electric (collectively "PG&E"). *See* 77 Fed. Reg. 58255 (Sept. 19, 2012).

NRDC has been actively engaged in this issue for more than one year. In the wake of the disastrous tsunami in northern Honshu, Japan, and the emergency at the Fukushima Daiichi Nuclear Power Station last year, we recognized that further study could be valuable for reassessing the earthquake risk at the Diablo Canyon nuclear reactor site. At the same time, we are profoundly concerned about the significant, adverse consequences that the project will have on marine life and marine habitat off the Central California coast, especially on the region's small population of harbor porpoises. We are also concerned that the benefits of the proposed project design have not sufficiently been defined.[1]

I. Our Recommendations Do Not Imply Support for the IHA

At the outset, we want to make clear that our recommendations here should not suggest affirmative support for PG&E's application.

[1] *See* Letter from Michael Jasny, NRDC, Kaitilin Gaffney, Ocean Conservancy, and Karen Garrison, NRDC, to Chair Mary Shallenberger and Members of the California Coastal Commission (Sept. 21, 2012) (attached).

First, NMFS should not authorize the project through an IHA rather than through an incidental take authorization. As you know, the MMPA makes IHAs available only to activities that injure or behaviorally harass marine mammals, not to those that have the potential to seriously injure or kill. 16 U.S.C. 1371(a)(5)(D). Any notion that the current project lacks potential to seriously injure or kill is belied by the efforts NMFS is presently making to monitor for strandings, especially of harbor porpoises. The monitoring and mitigation measures that NMFS intends to prescribe, together with PG&E's revised project design as represented in its most recent application to the California Coastal Commission, would reduce that potential, not eliminate it. Given the self-evident risk, NMFS should authorize such an activity only under a five-year take authorization.

Nor does the Environmental Assessment ("EA") prepared by the National Science Foundation provide an adequate basis for MMPA authorization. The EA makes fundamental errors in calculating marine mammal takes; provides poor qualitative analysis of the project's potential effects on wildlife populations; and, having failed to identify any potential for significant impacts, including impacts that would exceed the "small numbers" and "negligible impact" provisions of the MMPA, makes no serious effort at developing alternatives and other measures to mitigate them. Moreover, its analysis and conclusions are thoroughly inconsistent with the Environmental Impact Report (EIR) – a far more robust document – that the State Lands Commission has separately prepared under the California Environmental Quality Act, leaving the EA rightly vulnerable to challenge. And, of course, it begs credulity that NMFS could authorize so controversial and potentially harmful a project, a project whose marine mammal impacts the state's EIR found significant, without first preparing an Environmental Impact Statement. *See* 40 C.F.R. § 1508.27.

For these and other reasons, we cannot support issuance of the proposed IHA.

II. NRDC's Recommendations for Modifying the IHA

If, notwithstanding these significant problems, NMFS decides to issue the IHA, we urge it to make the following modifications.

(1) *Tailor the authorization to reflect the revised activity*

As you know, PG&E recently altered its plans for the first year of offshore survey activity, withdrawing a proposal to the California Coastal Commission that resembled its application to NMFS, and submitting a new one. This new proposal, among other things, reduces the first-year survey area from the whole of Boxes 2 and 4 to a portion of Box 4, and commits PG&E to provide funding for HARP ("High-Frequency Acoustic Recording Package") deployment and analysis.[2] To reduce conflicts with the "small numbers"

[2] *See* PG&E, Central Coastal California Seismic Imaging Project Updated Expanded Project Description: Revision No. 9 (Oct. 2, 2012) (submitted to California Coastal Commission as part of permit application No. EA-12-005) (attached).

requirement and other provisions of the MMPA, and to accurately reflect the project and its monitoring and mitigation measures, NMFS should authorize takes only from this revised description of the activity.

(2) *Modify the adaptive management protocol*

Adaptive management is not a panacea given our limited ability to detect impacts from human activities on marine mammals. Nonetheless, it remains an integral element of NMFS' mitigation plan for Diablo Canyon, and a potentially important means of minimizing risk of harm to the Morro Bay harbor porpoise population. To strengthen the adaptive management provisions in the proposed IHA, we recommend the following modifications:

(a) *Lines of decision.*— NMFS should specify lines of decision and communication for adaptive management purposes, and clarify that data analysis, decision, and communication to PG&E must occur within a short period (e.g., no more than 24 hours) following data acquisition. Any decisions for or against suspending the offshore survey should be made by the Southwest Fisheries Science Center investigators running the monitoring effort. To ensure transparency, their reports should be made available to the public on a timely basis.

(b) *Management in the absence of aerial surveys.*— NMFS should specify how adaptive management will proceed if aerial surveys are scuttled due to inclement weather or high sea states. It is not clear that passive acoustic monitoring can provide data sufficient to determine whether a trigger has been met, in part because of the time necessary to retrieve and analyze the information and in part because the information they obtain may not comport with the standards NMFS develops for shut-down. NMFS should identify triggers relevant to retrievable, timely passive acoustic monitoring data; if that is not possible, the agency should presumptively suspend the offshore activity if aerial surveys cannot be conducted within a short period of time (e.g., two or three days, reflecting the metabolic needs of harbor porpoises) after the survey commences, unless strongly counter-indicated by another factor.

(c) *Bright line and gray line standards for displacement.*— NMFS should establish both bright line and gray line standards for harbor porpoise displacement outside core habitat and normal range. According to the proposed IHA notice, NMFS intends to set such triggers after baseline data is acquired, largely from aerial surveying, before the survey begins. NMFS should ensure that the triggers include both bright line rules, which would apply once certain observations are made (e.g., numbers of animals occurring outside core habitat) without any subjective decision-making from the agency; and gray line standards, which would require some further evaluation and decision by investigators. Bright-line rules aid transparency and are important to ensuring public confidence in the monitoring effort.

(d) *Triggers for other types of disruption.*— NMFS should establish triggers for other types of harbor porpoise disruption. As it stands, the triggers set forth in the proposed IHA notice cover pre-stranding milling behavior and displacement of harbor porpoises outside core habitat, but not massive displacement within the population's core habitat or other potentially harmful behaviors. NMFS should identify other unusual behavior for adaptive management purposes, such as the presence of unusual numbers of harbor porpoises within the array's 160 dB isopleth.

(e) *Stranding triggers for harbor porpoises.*— NMFS should apply a slightly more conservative standard to harbor porpoise strandings. Under the proposed IHA, the simultaneous stranding of any two marine mammals, or the stranding of at least two cetaceans within a day or three within a week would trigger adaptive management. While reasonable for other species, we believe that these thresholds are not sufficiently conservative for harbor porpoises. Given the virtual absence of any recorded strandings of harbor porpoises in the area, and given that porpoise strandings could signal adverse health effects within the population as a whole, we recommend establishing an absolute threshold of "1" for harbor porpoise strandings.

(f) *Management during necropsies.*— NMFS should suspend the offshore survey during necropsies of dead stranded animals, if the number of stranded animals otherwise exceeds NMFS' triggers. Under the proposed IHA, NMFS would first perform a "detailed necropsy with diagnostic imaging scans to rule out obvious cause of death," before deciding whether a Phase 2 investigation is performed – potentially triggering adaptive management. Yet such an analysis could take several days or more, quite possibly precluding results before the survey is completed. For obvious reasons of precaution, the offshore survey should be suspended pending the results of the necropsy, if NMFS' numerical triggers are otherwise met.

(g) *Adaptive management for baleen whales.*— NMFS should clarify its role in enforcing the existing baleen whale adaptive management provision. The EIR requires pre-survey monitoring for blue, fin, and humpback whales and establishes triggers for adaptive management based on particular densities. If these densities are exceeded, PG&E must "consult" with both NMFS and the California State Lands Commission about "potential strategies" to mitigate harm. NMFS should clarify that, as principals in the monitoring effort, it will independently determine whether densities are exceeded and, in such a case, as the expert federal agency, will consider prescribing additional mitigation independent of any consultation with PG&E and the State Lands Commission.

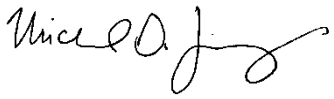
(3) *Undertake monitoring activity regardless of seismic survey approval*

Finally, NMFS should commit to aerial and passive acoustic monitoring even if PG&E's state permit application is ultimately denied. As you know, PG&E's application to the California Coastal Commission is facing significant opposition from the public, and its

approval is by no means assured. Given that NMFS has already begun deploying passive acoustic monitoring devices, and should have flown several aerial surveys by the Commission's hearing date in mid-November, we urge NMFS to complete data acquisition and analysis regardless of the outcome, and to obtain PG&E's agreement to fund this effort regardless. Obtaining baseline data on harbor porpoise distribution, habitat use, and calving seasonality is essential to informing any future MMPA take application.

We appreciate the opportunity to discuss these issues with you and your staff. For further discussion, please do not hesitate to contact Michael Jasny (310-560-5536, mjasny@nrdc.org).

Very truly yours,



Michael Jasny
Director, Marine Mammals
NRDC

Karen Garrison
Co-Director, Oceans Program
NRDC

Kaitilin Gaffney
Pacific Program Director
Ocean Conservancy

ITP Goldstein <itp.goldstein@noaa.gov>

Comments on the Calif. Central Coast Seismic Surveys

Michael Stocker <mstocker@ocr.org> Wed, Oct 10, 2012 at 7:54 PM
To: ITP.Goldstein@noaa.gov
Cc: gwynn dandridge-perry <gwynndp@gmail.com>

Re: Federal Register / Vol. 77, No. 182 /RIN 0648–XC072

Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California

Comments attached. Also sent by US Mail.

Michael Stocker, Director

Ocean Conservation Research

P.O. Box 559

Lagunitas, CA 94938

V. 415-488-0553

www.OCR.org

Diablo Canyon Seismic Surveys OCR Comments.pdf
132K

OCEAN CONSERVATION RESEARCH

Science and technology serving the sea

October 10, 2012

Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910-3225

Re: PG&E/Lamont Doherty California Central Coast seismic imaging project.

Dear Mr. Payne,

We are concerned that the proposed seismic survey of the geological profile of the areas offshore from the Diablo Canyon nuclear power plant are poorly planned and thus will be unnecessarily disruptive to marine life. While we do not believe that the seismic surveys will immediately destroy all marine life in the region as some opponents fear, it is well known that even shipping noise (without seismic airgun signals) increases stress levels in whales[1]. We also know that airgun pulse exposure levels significantly lower than the 160dB "safety zone" will disrupt migration patterns − with the potential to compromise reproductive success of whales[2]. Additionally there is ample evidence that seismic surveys disrupt foraging in sperm whales,[3] and interrupt the vocalizations[4] and "spook"[5] Bowhead whales.[6]

[1] Rosalind M. Rolland, Susan E. Parks, Kathleen E. Hunt, Manuel Castellote, Peter J. Corkeron, Douglas P. Nowacek, Samuel K. Wasser and Scott D. Kraus (2012) "Evidence that ship noise increases stress in right whales" Proc. R. Soc. B doi:10.1098/rspb.2011.2429

[2] Castellote, M. Clark, C.W., Lammers M.O. "Potential negative effects in the reproduction and survival on fin whales (Balaenoptera physalus) by shipping and airgun noise." International Whaling Commission report SC/62/E3 - 2010

[3] Jochens, A., D. et.al . 2008. Sperm whale seismic study in the Gulf of Mexico: Synthesis report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2008-006. 341 pp.

[4] Blackwell, S. B., Nations, C.S.S., McDonald, T.L., Greene, C.L., Thode, A., Macrander, M.A. "Effects of sounds from seismic exploration on the calling behavior of bowhead whales. (A) 2008 J. Acoust. Soc. Am. V124: 4

[5] Richardson, J.W., Wursig, B., Greene, C.W. "Reactions of bowhead whales, *Balaena mysticetust* to seismic exploration in the Canadian Beaufort Sea" J.Acoust. Soc. Am 79 (4), l986

[6] While sperm whales are not common in the area, and Bowheads are an Arctic species, it stands to reason that these species could serve proxy for other mysticetes and odontocetes.

Box 559, Lagunitas, California 94938
V. 415.488.0553 F. 415.488.1725
www.OCR.org

We also know that seismic surveys have agonistic effects on fish species[7], can cause intermediate to long-term damage to fish hearing mechanisms[8], damage fish eggs, larvae and fry[9], and can also damage[10] and kill marine invertebrates[11].

All of these citations point to the fact that while seismic surveys may not always induce these agonistic, damaging, or deadly interactions, they should be avoided. This is particularly in light of the scheduling of the surveys that overlap the fall migration of Eastern Pacific gray whales.

It is an unfortunate happenstance that Table 4-1 "Estimated Densities of Marine Mammal Species Within the 160 dB Seismic Survey Safety Zone by Survey Area" in the Draft Environmental Assessment[12] does not have NOAA density estimations for this species, the "Padre Density" Transit and Transects were taken in December through February when most of the whales have reached their southern destination in the lagoons of Baja California. Had these surveys taken place in November and December – to coincide with the proposed seismic survey operations, the densities would likely have been much higher. That many of the gray whales migrating past the subject area in the late fall are also pregnant females highlights the level of poor planning in this aspect of the larger program.

The objective of the entire program is to determine if the level of seismic instability in and around the Diablo Canyon Nuclear Power Plant puts the plant at risk of catastrophic failure in the event of an earthquake. We believe that the proposed marine seismic airgun surveys need to be weighed in terms of a balance of harms. Should there be a large scale seismic event the potential for loss of life and habitat is extremely high, but we believe that if better planned and staged, the geological evidence substantiating the risks could be determined without needing to survey such large areas – or even any of the marine geological profile off of Diablo Canyon.

Bearing in mind that I am not a geophysicist, and strategizing the sequence of the entire program is not under the purview of the National Marine Fisheries Service I only offer the following argument to substantiate our opinion that any "Incidental Harassment" or "Incidental Take" permits should be denied until it is determined that the information assuring safe operation on the power plant could only be secured by way of towed airgun seismic surveys.

---

[7] Engås, A. S. Løkkeborg, E. Ona, and A.V. Soldal. (1996). "Effects of seismic shooting on local abundance and catch rates of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*)". Can. J. Fish. Aquat. Sci. 53:2238-2249.

[8] McCauley, R. D., Fewtrell, J. & Popper, A. N. (2003). High intensity anthropogenic sound damages fish ears. Journal of the Acoustical Society of America 113, 638–642

[9] J. Dalen and G.M. Knutsen, "Scaring Effects on Fish and Harmful Effects on Eggs, Larvae, and Fry by Offshore Seismic Explorations" in H.M. Merklinger, Progress in Underwater Acoustics 93-102 (1987);

[10] Michel André et.al. 2011. "Low-frequency sounds induce acoustic trauma in cephalopods. Frontiers in Ecology and the Environment" 9: 489–493. http://dx.doi.org/10.1890/100124

[11] A. Guerra, A.F. González and F. Rocha (2004) "A review of the records of giant squid in the north-eastern Atlantic and severe injuries in *Architeuthis dux* stranded after acoustic explorations" International Council for the Exploration of the Sea CC:29

[12] Padre Associates "Draft environmental assessment of marine geophysical surveys by the R/V Marcus G. Langseth for the central coastal California seismic imaging project" June 2012 p. 117-119.

I understand that there is substantial data on the Shoreline, Hosgri, Los Osos, and San Luis Bay faults that may already preclude continued operation of the power plant. I understand that the first three of these are not seafloor faults, could be surveyed from terrestrial vibroseis, and modeled in greater detail to assure that the risk-threshold for safe plant operation is not already exceeded by what we know.

If further data is needed it is possible that a general profile of the entire area could be derived from "Full Tensor Gravity Gradiometry" (FTG)[13] surveys. These might be conducted from airborne[14] or marine towed[15] instruments. If these surveys did not yield the level of detail required for a clear decision, they would likely help focus in on where seismic excitation would yield the most productive data.

And if seismic excitation is still indicated, this setting would be an opportune site for the use of marine vibroseis or other less impulsive energy source.[16] These alternate technologies are non-impulsive and distribute the excitation signal over a longer time domain, and while they may be behaviorally disruptive, they typically would not exceed the current acoustical exposure mitigation thresholds found in the Marine Mammal Protection Act (MMPA).

Of course none of these alternatives will be employed if NMFS issues permits to proceed with the current plan. For this reason we ask that you deny the Incidental Harassment and Incidental Take permits requested by PG&E for the marine seismic surveys off of California's Central Coast.

Sincerely,

Michael Stocker

[13] http://www.arkex.com/blueqube.html
[14] http://www.bellgeo.com/Air_FTG/Air_FTG.html
[15] http://www.bellgeo.com/Marine_FTG/Marine_FTG_introduction.html
[16] Weilgart, L.S. (ed) 2010. Report of the Workshop on Alternative Technologies to Seismic Airgun Surveys for Oil and Gas Exploration and their Potential for Reducing Impacts on Marine Mammals. Monterey, California, USA, 31st August – 1st September, 2009. Okeanos - Foundation for the Sea, Auf der Marienhöhe 15, D-64297 Darmstadt. 29+iii pp. Available from http://www.sound-in-the-sea.org/download/AirgunAlt2010_en.pdf

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Milla de Villiers <edenoutreach@live.co.za>
To: itp.goldstein@noaa.gov

Sun, Oct 14, 2012 at 12:20 PM

Dear Mr. P. Michael Payne,

RE: Marine Geophysical Survey off the Central Coast of California, November to December, 2012

It is with deep concern that I note the willingness of authorities to ignore the threats of the planned marine geophysical survey off the central coast of California, Nov – Dec 2012. The projected total of 33 MILLION animals being affected is serious in the extreme and cannot be ignored. Neither can any benefit from this exploitation in any way compensate for this impact: money cannot replace life, and deliberate ecocide is both irresponsible and unforgivable.

I hesitate to even touch on how unethical it is to manipulate the public into believing that such an action is for their good or unavoidable. Apart from the many deaths and injuries that WILL result, he sheer trauma this will cause marine animals should already pose a complete barrier to these actions even being considered. Finally: these animals are not the possessions of the US government. Many are migratory, and all form part of the ecosystem we all hold as a common heritage.

We owe it to our children, if nothing else, not to continue destroying and exploiting our environments through what boils down to greed. Responsible, ethical, transparent actions would require that both the Navy and Big Oil should be required to prove with 100% certainty that their activities DO NOT cause any harm to marine life before any consideration of proceeding should be taken.

My concerns:

1. Proposal downplays the potential effect on marine life including fish, invertebrates and marine mammals.

2. Important studies that linked seismic surveys to strandings are not mentioned in proposal. Specifically the report by Gentry (2000) called "Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000"is not mentioned, let alone discussed in detail. Report by Malakoff 2002 called"Suit ties whale deaths to research cruise" (Gulf of California 2002) only mentioned briefly without significant discussion. Other occurrences such as Madagascar stranding are not mentioned at all.

These are documented cases that have not been mentioned in proposal

1. Mozambique 2006,

2. Gulf of California, 2002

3.Galapagos Islands, 2000

4. Madagascar, 2008

5. Peru, 2012

6. Interesting Statistics from Australia (2002-2004)

3. Crucial study that showed Cardiorespiratory Changes in Beluga Whale in Response to Acoustic Noise is not even mentioned in proposal. In this study belugas were exposed to noise at much lower level than is planned in California and the animal demonstrated severe tachycardia "at lower noise intensities (as low as 140 dB);"

4. This proposal is rushed and the levels of impact are not investigated enough and not accessed based on the best scientific evidence available.

5. The company's planned actions lack transparency, they should be required to fully and publicly disclose where activities take place, what equipment will be used, exact Sound Pressure Levels, when activities will take place. Additionally, marine mammal observers' logs where they record all marine mammal sightings should be publicly available.

6. The proposal lacks specifics of how strandings will be investigated. It does not include what protocol of stranding investigation will be, what independent organizations will investigate strandings, who and in what manner will look for the evidence of acoustic trauma, decompression sickness related embolism, hemorrhage, etc.

7. NMFS should deny the permit based on omission of the best scientific evidence available and inadequate assessment of impact on marine life.

Bottom Line:

1. MASS AND SINGLE STRANDINGS ARE NOT INVESTIGATED AND NOBODY SEARCHES FOR EVIDENCE TO LINK BIG OIL OR THE NAVY TO STRANDINGS.

2. BIG OIL (AND NAVY) DO NOT DISCLOSE WHERE, WHEN AND WHAT THEY HAVE BEEN DOING AND NOBODY ASKS THEM TO SHARE THIS INFORMATION PUBLICLY.

With such huge gaps in data, with strandings going down not-investigated and with Big Oil/Navy not being required to disclose data about their activities, it is irresponsible, wrong and insane to grant these permits, especially for sanctuaries and protected areas. This is insanity. Two recent examples: Peru die off and Black Sea die off.

Please submit my comments for consideration before reaching a decision, and may I ask that these comments be posted to http://www.nmfs.noaa.gov/pr/permits/incidental.htm#applications, without change, as per your guidelines. Please feel free to contact me should you have any queries.

Here are the links for the above points:

· Suit Ties Whale Deaths to Research Cruise by David Malakoff, Science 25 October 2002: 722-723. http://www.sciencemag.org/content/298/5594/722.citation

· Mozambique 2006 http://www.iol.co.za/scitech/technology/seismic-float-twists-stranding-of-dolphins-1.301955

· Gulf of California 2002 = Suit Ties Whale Deaths to Research Cruise by David Malakoff, Science 25 October 2002: 722-723.http://www.sciencemag.org/content/298/5594/722.citation

· Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000

• *by Roger L. Gentry, November 4, 2002* http://www.nmfs.noaa.gov/pr/pdfs/health/galapagos_stranding.pdf

· Whales stranded off Madagascar By Jonny Hogg BBC News, Antananarivo http://news.bbc.co.uk/2/hi/africa/7443559.stm

• Peru 2012 – Medical findings https://docs.google.com/file/d/0BzPA6tiYhZyhX1I6T1Q5MHZqd1U/edit?pli=1#

· Interesting Statistics from Australia (2002-2004) Oceania Strandings http://www.whales.org.au/

strandings/oceania/index.html

· Cardiorespiratory Changes in Beluga in Response to Acoustic Noise

· O. I. Lyamin*a*, *b*, *c*, S. M. Korneva*b*, V. V. Rozhnov*a*, and L. M. Mukhametov*a, b*

- Presented by Academician D.S. Pavlov June 15, 2011 http://beluga.sevin-expedition.ru/netcat_files/106/57/11_Lyamin_ECG_acoustic_noise_beluga_DAN_E.pdf

Thank you,

Ms. M de Villiers

Founding Director and CEO: Eden Outreach Sustainable Solutions

edenoutreach@live.co.za

Need a Number Plate? A few CLICKS and it GETS DELIVERED
VuvuPlaza Get your Number Plate on VuvuPlaza

NiQqui
NiQqui offers calls for less
niQqui

Seismic float twists stranding of dolphins

November 7 2006 at 12:40pm
By Tony Carnie

The mystery surrounding the stranding of nearly 40 bottlenose dolphins on a Mozambican island has deepened with the discovery of Norwegian-made seismic survey equipment in the sea near Bazaruto.

The South African petro-chemical group Sasol is planning to conduct a seismic survey for hydrocarbon gases close to the Bazaruto Archipelago National Park in 2007, but denies it has done any preliminary survey work using underwater sound guns because of the uncertain safety risks for endangered sea creatures such as the dugong.

However, the Maputo-based environmental group Eyes on the Horizon has produced photographs of a large orange seismic float bearing the markings: "Scanmarin. Seismic float, type SSF 1000. Made in Norway by Bakelittfabrikken A/S."

A spokesperson for a Norwegian company previously involved in making these seismic floats told The Mercury he could not speculate on when the device was made or who owned it, since a large number had been made over the past two decades.

However, University of KwaZulu-Natal dolphin expert Vic Peddemors has suggested that several of the dolphins which died last weekend may have been dumped overboard as bycatch from a fishing vessel.

The former Natal Sharks Board scientist, who is working at Macquarie University in Australia, said he had examin-ed e-mailed photos of some of the stranded corpses, and had noticed peculiar marks on their skin that suggested they might have been caught in fishing nets and then dumped as bycatch.

These marks might have been caused by ropes or nets. What complicated this theory, he said, was the fact that several animals were reported to have been alive when they beached.

"However, it could be that they were weak, but still alive, when released from the nets and barely managed to stay afloat on release.

"The reason I'm still considering the case for bycatch is the number of animals that I believe show evidence of rope marks."

Nevertheless, the discovery of the Norwegian seismic float has also raised questions.

Commenting on photographs e-mailed to him by The Mercury, Dag Eirik Thomassen, of the Oslo-based Polimoon Group, said the float could have been made 10 years ago or within the past year.

Barnacle and algae growth, evident in the photos, could start quite quickly and be visible within five to six months.

He said Scanmarin and Bakelittfabrikken were previously associated with his company in manufacturing such floats. "We still have the name Scanmarin on some of the polyethylene moulds we use, even though that company no longer operates."

Thomassen said the device in question was probably a foam-filled flotation buoy, containing no specialised sound equipment.

They were used to prevent the long arrays of floating seismic equipment from sinking while being towed by survey vessels.

Seismic marine surveys involve blasting short bursts of sound bubbles from several air guns. These sound blasts are directed at the ocean floor and reflected back to floating hydrophones (recording equipment), which are then relayed to the survey ship for interpretation.

According to an environmental impact assessment report of the proposed Sasol gas exploration

Most Viewed

- I wanted to come back alive - Baumgartner
- Video: Baumgartner's headcam footage
- Ebooks take erotic literature to new heights
- SA easy target for cyber criminals
- Daredevil prepares for space jump

Join us on

scheme, only limited scientific research was conducted on the effects of seismic surveys on dolphins.

While there is some evidence that dolphins had been seen swimming close to seismic survey vessels, other research indicated that dolphins and whales reacted by swimming rapidly away from the source of the gun blasts.

The report suggested that there was some risk of injuring the hearing systems of dolphins and whales, and the possibility of fatal strandings.

"The case studies suggest that both fatal trauma and behavioural avoidance (leading to fatal strandings) can occur from high-level acoustic impulses," the report said

It noted that sound from underwater seismic surveys (at about 250 decibels) could be heard up to 50km away by some creatures.

One study suggested that bowhead whales actively avoided seismic gun noises and began to swim rapidly away when the approaching survey ship was 24km away.

To protect humans from injury, international regulations recommend that divers or bathers leave the water when surveys are under way.

Sasol issued a statement last week in which they emphatically denied that they were involved at present in any seismic surveys around Bazaruto. There have been numerous reports of mass dolphin strandings throughout history, and researchers have said avariety of natural causes or human factors could be responsible.

Recommend Be the first of your friends to recommend this.

0

Property Classifieds Motors

Atholl
R 7,800,000
5 Bedroom(s)
5 Bathroom(s)
View Details
Search

I wanted to come back alive - Baumgartner

Is Felix Baumgartner crazy for attempting the first space jump?

Yes No Felix who?

Vote now

I wanted to come back alive - Baumgartner

iOL mobile.co.za
Find out more about m.iol.co.za and personalise your phone with the latest downloads.

iOL travel.co.za
Make sure you find the best available airfares with our easy-to-use search engine.

© Copyright 1999 - 2012 Independent Online, a division of Independent Newspapers (Pty) Limited. The copyright in the literary and artistic works contained in this online news publication and its other related and connected websites, as well as in the published editions of group newspapers, their supplements and any other content or material, belongs exclusively to Independent Newspapers (Pty) Limited unless otherwise stated.
The reproduction of any content or material contained in this online news publication and its other related websites as well as the published editions of group newspapers and their supplements is expressly reserved to the publisher, Independent Newspapers (Pty) Limited, under Section 12(7) of the Copyright Act of 1978. Reliance on the information contained in the online news publications and other related content published on this website is done at your own risk and subject to our "terms and conditions". Independent Newspapers (Pty) Limited has committed itself to The Press Code of Professional Practice which prescribes that news must be reported in a truthful, accurate, fair and balanced manner. If we don't live up to the Press Code please contact The Press Ombudsman

2nd Floor, 7 St David's Park, St David's Place, Parktow n, 2193 or PO Box 47221, Parklands 2121 or email pressombudsman@ombudsman.org.za (w w w .ombudsman.org.za) or telephone 011 484 3612/8.

Cookies on the BBC website

We use cookies to ensure that we give you the best experience on our website. We also use cookies to ensure we show you advertising that is relevant to you. If you continue without changing your settings, we'll assume that you are happy to receive all cookies on the BBC website. However, if you would like to, you can **change your cookie settings** at any time.

Continue

Find out more

ADVERTISEMENT

Page last updated at 09:38 GMT, Monday, 9 June 2008 10:38 UK

E-mail this to a friend Printable version

Whales stranded off Madagascar

By Jonny Hogg
BBC News, Antananarivo

A mission is under way to rescue more than 100 whales trapped in a bay in the north of Madagascar.

Marine noise has been known to disorientate whales in the past

About 30 whales have already died and experts are being flown in from across the world.

The site is near an area where ExxonMobil is carrying out seismic surveys but the oil company has denied any link.

The first whale became stranded at the end of May and the first fatality was reported three days later.

Surveying suspended

The majority of the melon-headed whales swam through a narrow entrance into a bay where they have become trapped.

ExxonMobil had been carrying out seismic surveying in the area, although it says this began several days after the first whale washed ashore.

However, it told the BBC it had been using echo-sounding before this.

The company said it is confident it is not responsible, given that its operation was over 50km (31 miles) away from the Baie de Loza, where the whales have been washed up.

Despite this, it has halted its surveying programme until the issue has been resolved.

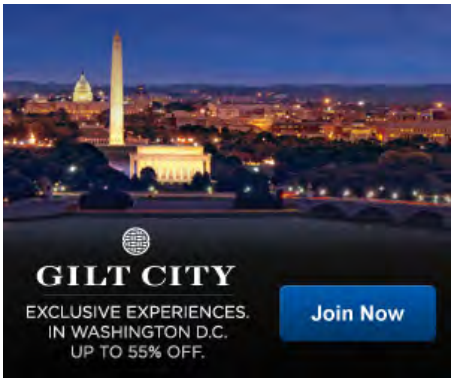
Meanwhile, a rescue effort involving local people and international conservation agencies is under way to save the remaining animals.

E-mail this to a friend Printable version

Bookmark with: What are these?

Delicious Digg reddit Facebook StumbleUpon

ADVERTISEMENT



SEE ALSO
In pictures: Senegal's beached whales
22 May 08 | In Pictures
Research needed on marine sound
13 Feb 06 | Science/Nature
Country profile: Madagascar
06 Feb 08 | Country profiles

RELATED INTERNET LINKS
ExxonMobil

The BBC is not responsible for the content of external internet sites

TOP AFRICA STORIES
Nigeria state oil firm 'insolvent'
France to help Africa veterans
Churches call for Sudan to split

| News feeds

MOST POPULAR STORIES NOW
SHARED | READ | WATCHED/LISTENED
Skydiver smashes YouTube record
Pilot lands jet at wrong airport
Girl shot by Taliban reaches UK
Skydiver surpasses speed of sound
Planet with four suns disovered
Why are the British so bad at washing

Why are the British so bad at washing their hands?

Independence 'battle lines' drawn

Gurkha veteran 'unaware of blade'

Five daredevils who helped science

The Bronx school that produces Nobel winners

Most popular now, in detail

FEATURES, VIEWS, ANALYSIS

Ghost town
Has China's housing bubble burst?

The guerilla plant
How the world's oldest clove tree defied an empire

Walking away
Why Royal Ballet principal Sergei Polunin quit

MOST POPULAR NOW | The most read story in North America is: Town lines 'make road dangerous'

SKIP TO TOP

PRODUCTS & SERVICES E-mail news Mobiles Widgets & Alerts News feeds Podcasts

BBC

BBC © 2012 The BBC is not responsible for the content of external sites. Read more.

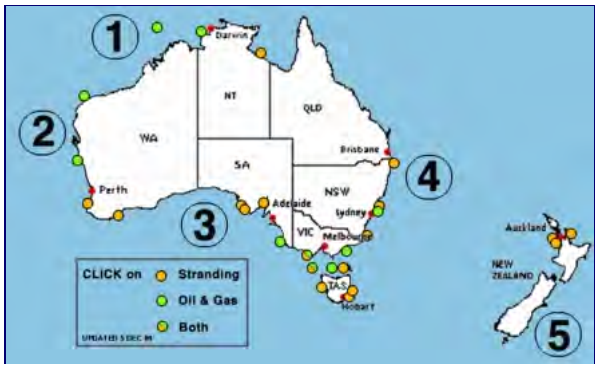
Mobile site
Advertise With Us
Ad Choices

Terms of Use
Privacy
Cookies
Parental Guidance

About the BBC
BBC Help
Accessibility Help
Contact Us

Oceania Strandings

"During seismic work in 2000, no blue whales swam within 95 kilometres of the testing," says whale expert Peter Gill, of Deakin University, Victoria.



Australian Seismic Survey Guidlin

Stranding

5 - Whaipu Beach, Karekare, North Is, NZ	SOUTHEAST	Nov04
3 - Darlington Bay, Maria Is.	SOUTHERN	Nov04
5 - Opoutere Beach, North Is, NZ.	SOUTHEAST	Nov04
3 - Sea Elephant Beach, King Is.	SOUTHERN	Nov04
3 - Whitemark, Flinders Is.	SOUTHERN	Nov03
3 - Port Bonython, SA.	SOUTHERN	Nov03
3 - Point Hibbs, Tas.	SOUTHERN	Nov03
3 - Streaky Bay, SA.	SOUTHERN	Nov03
5 - Auckland, NZ.	SOUTHEAST	Nov03
2 - Busselton, WA.	WESTERN	Feb03
2 - Tooregullup Beach, WA.	WESTERN	Jul02

Oil & Gas

2004	SOUTHERN	ESSO Australia P/L - Seismic S
2004	WESTERN	ROC Oil P/L - Seismic Survey
Jan/Feb/Mar04	EASTERN	Bounty Oil & Gas - Seismic Sur
Nov03	WESTERN	Bounty Oil & Gas - WA325P
Nov03	SOUTHERN	Woodside Energy - Seismic Su
2003	NORTHERN	Bounty Oil & Gas - WA324P
Oct02	WESTERN	Santos - WA191P
2002	NORTHERN	Bounty Oil & Gas - AC/P25

Science Prev | Table of Contents | Next

Science

www.sciencemag.org
Science 25 October 2002:
Vol. 298 no. 5594 pp. 722-723
DOI: 10.1126/science.298.5594.722

- NEWS OF THE WEEK

SEISMOLOGY

Suit Ties Whale Deaths to Research Cruise

David Malakoff

Last week an environmental group asked a federal judge to suspend a National Science Foundation (NSF)-funded sea-floor mapping expedition off Mexico that it claims led to the deaths of two whales. NSF rejects a link between the deaths and the air guns used by shipboard researchers to generate sound waves, but the incident has nonetheless reignited controversy over the impact of noise on marine mammals.

Read the Full Text

Mass Stranding of Beaked Whales
in the Galapagos Islands, April 2000
by Roger L. Gentry, November 4, 2002

Background

This stranding of beaked whales in the Galapagos Islands in 2000 was first reported to NMFS on October 24, 2002 by Dr. Bruce Mate of Oregon State University. Dr. Mate, Mr. Daniel Palacios, and Dr. Jorge Urban of the Autonomous University of Baja California Sur were discussing the stranding of two beaked whales (*Ziphius cavirostris*) in the Gulf of California on September 24, 2002. When it was mentioned that the NSF-supported *R/V Maurice Ewing* had been conducting a seismic airgun survey in the area at the time, Mr. Palacios recalled that the same vessel had been conducting a seismic survey off the Galapagos Islands in April 2000 when four *Z. cavirostris* stranded on Santa Cruz Island. He had not previously mentioned this coincidence to anyone, he did not notify the *R/V Maurice Ewing* at the time, and the stranding was never reported publically. The three decided to report this event to NMFS in view of a legal action then pending against NSF for continuing the *R/V Maurice Ewing's* survey of the Gulf of California. They reported it to Dr. Roger Gentry at the NMFS Office of Protected Resources who compiled this report.

Those who contributed the facts below were Mr. Palacios, Dr. John Sinton (PI on the Galapagos cruise), the National Science Foundation (NSF), Lamont-Doherty Earth Observatory (operators of the *R/V Maurice Ewing*), and Mr. Godfrey Merlen and Ms. Sandi Salazar both of the Charles Darwin Research Station in the Galapagos.

Synopsis of the Galapagos Stranding

The following report of the stranding was written by Ms. Salazar, and was translated into English on October 25, 2002 by Daniel Palacios.

Day: 11 April (2000)
Time: 06:00 am (approx.)
Island: Santa Cruz
Site: Tortuga Bay (to the north of Playa Brava)
Species: *Ziphius cavirostris*
Number of individuals: 3 adults; 2 individuals were stranded on rocks and they were rescued and taken to deeper waters. The only individual that stranded on sand died after at least two hours of the sighting.

> **Dead individual:**
> **Age/class:** adult
> **Length:** 5.10 m
> **Primary color:** gray
> **Secondary color:** white
> **Markings on the sides:** white circles
> **External lesions:** absent
> **Possible causes of death:** Asphyxia (there was presence of sand in the blowhole)
> **Stomach content:** several beaks of cephalopods.

The stranding site is shown in Figure 1. The dotted line shows the deep water approach to the stranding site. There is no evidence the whales actually followed this route. The whales that were pushed off were not sighted again. Note that Mr. Merlen's necropsy report (below) states that four animals were seen. That number is adopted as the number involved.

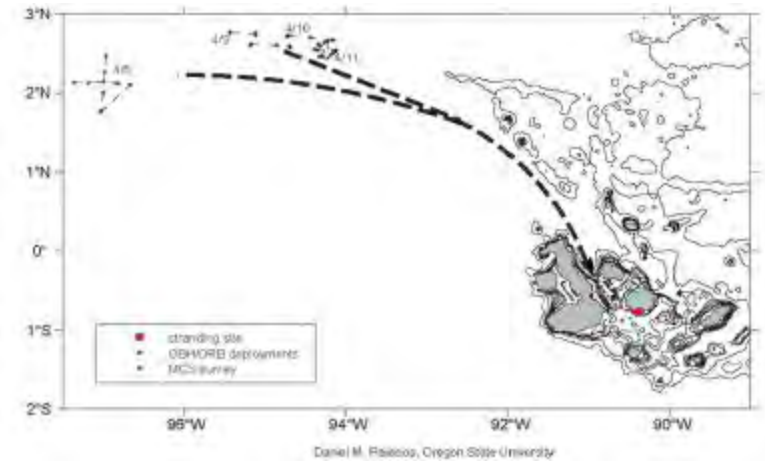


Figure 1. Location of the April 11, 2000 stranding of four *Ziphius cavirostris* on Santa Cruz Island, Galapagos. The dotted line shows the deep water approach to the stranding site.

Necropsy Report

A necropsy was performed on the dead whale by Godfrey Merlen, Sandi Salazar and assistants. They did not write a necropsy report at the time. On request, Mr. Merlen wrote an informal description of their findings, based on his field notes, on October 29, 2002. The pertinent part of this report is as follows:

"As far as the stranding goes it seems that there was at least one whale that did not strand and was seen at sea off the beach. Two we got off the beach and they were not reported again on the shore anywhere. I guess they could have died at sea? The third died in the surf as there were not enough people to attend to them all. Probably of overheating and pressure as the lungs were empty of water. I cut this animal up as a specimen. None of the three was bleeding from the head. I did not notice any damage around the ears or any internal bleeding. The ear bones were complete and in place. The lower jaws complete. Of course I do not claim to be a specialist at looking for this kind of damage but I have dissected a few heads and found this one normal. The stomach, as reported, contained squid beaks but no squid. As I have no idea how long it takes to digest a squid I cannot say when this animal last fed. There were no other sign of damage, externally or internally, except for the round or crescent shaped scars on the body".

Mr. Merlen stated that they did not open the skull during the necropsy.

Activities of the *R/V Maurice Ewing*

Mr. Palacios learned that the *R/V Maurice Ewing* was operating an airgun array in the vicinity on April 15 while he was conducting a marine mammal survey. The *Ewing* informed him by VHF radio that they had gear in the water. On his return to port, Mr. Merlen informed him about the beaked whale stranding on April 11.

Full information about the seismic array used on this cruise and about the ship's track line are available from the Woods Hole Oceanographic Institution Marine Seismology Group.

Figure 2 shows the track line of the *R/V Maurice Ewing* from April 6 to April 11 (provided by the Lamont-Doherty Earth Observatory). It shows the ship was moving generally from west to east during this period. On April 11 it was closer to the islands than on any previous day of the cruise, and was then 270 nmi from the northwest corner of Santa Cruz Island. The whales stranded on the southern side of this island.

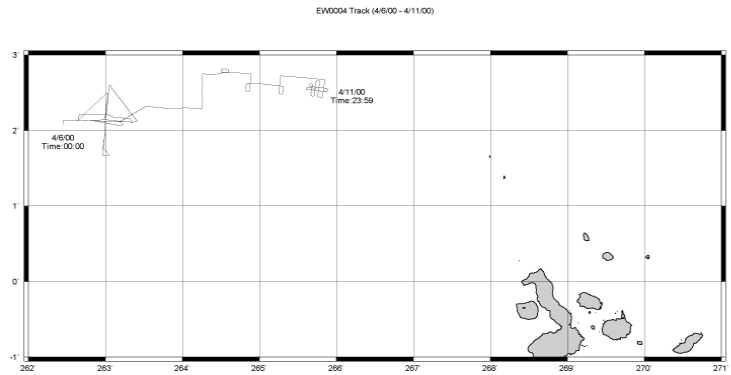


Figure 2. Track line of the *R/V Maurice Ewing* while operating seismic airgun arrays from April 6 through April 11, 2000. On April 11, it was still approximately 270 nmi from the northwest corner of Santa Cruz Island.

On April 6 and 7 the ship was towing a 20 airgun array and was approximately 400 nmi from the stranding site. From April 9 to 11 it was towing a 10 gun array and was at closest 270 nmi from the standing site. Lamont-Doherty is presently recalculating the source levels of the airgun array in these two configurations so they can be more readily compared with the output of commercial airgun arrays.

Discussion

The necropsy report is inconclusive. It did not find trauma of the type that is typically associated with acoustic sources (hemorrhage in acoustic fats, around the eyes or ear bones, see Interim Report of the Bahamas Beaked Whale Stranding; 2001). On the other hand, it did not examine the brain, which sometimes shows hemorrhages when animals have been exposed to intense sound fields. Therefore, the necropsy report can neither confirm nor deny acoustic injury. In its present form the report does not rule out infection, starvation or other causes.

It is not feasible that the sound field from the *R/V Maurice Ewing* affected animals that were resident near the stranding site. Since spreading loss causes the intensity of a sound to drop by a factor of 4 with each doubling of distance from the source, the level at more than 200 nmi would have been well below the levels known to cause tissue damage in laboratory animals. There is no mechanism presently known by which beaked whales could have been affected by an acoustic source at such a distance.

It is possible that these beaked whales were exposed close to the ship and swam to the stranding site thereafter. Field measurements show that healthy marine mammals can swim at 3 meters per

second and thereby could cover 270 nmi (500 km) in 48 hours. Whether animals that have been disoriented or injured by an airgun array could have done so is not known.

Conclusions

It is not possible to conclude whether the *R/V Maurice Ewing* was involved in this stranding. Cause and effect can only be determined from necropsy results which, in this case, were inconclusive. Correlation does not substitute for cause and effect, but it can indicate whether certain causes are feasible. In this case, the stranding and the seismic survey were correlated in time, but not in space. There is no obvious mechanism that bridges the distance between this source and the stranding site. Therefore, the cause remains indeterminate.

Literature Cited

U.S. Department of Commerce, and Secretary of the Navy. 2001. Joint Interim Report Bahamas Marine Mammal Stranding Event of 14-16 March 2000. [pdf] [1.5 MB] (Unpublished report.)

ISSN 0012-4966, Doklady Biological Sciences, 2011, Vol. 440, pp. 275–278. © Pleiades Publishing, Ltd., 2011.
Original Russian Text © O.I. Lyamin, S.M. Korneva, V.V. Rozhnov, L.M. Mukhametov, 2011, published in Doklady Akademii Nauk, 2011, Vol. 440, No. 5, pp. 704–707.

PHYSIOLOGY

Cardiorespiratory Changes in Beluga in Response to Acoustic Noise

O. I. Lyamin[a, b, c], S. M. Korneva[b], V. V. Rozhnov[a], and L. M. Mukhametov[a, b]

Presented by Academician D.S. Pavlov June 15, 2011

Received June 17, 2011

DOI: 10.1134/S0012496611050218

Acoustic noise is one of the most important factors of anthropogenic action on marine mammals. The majority of studies of noise influence on marine mammals to date have dealt with the connection between noise parameters and subsequent changes in animals' hearing. The influence of noise on the physiological condition of cetaceans has been poorly studied [1]. The heart rate (HR) and respiratory rate are objective indices that may be used for evaluation of an animal's condition. In many studies, HR is used for the assessment of reactions and conditions of the autonomic nervous system of humans and animals in anxiety and stress [2, 3], as well as under the action of different external stimuli [4], including acoustic noise [5]. The only study conducted on one bottlenose dolphin indicated that HR in animals accelerated upon hearing the audio recording of whistling of other animals [6]. The aim of this research was to study the influence of acoustic noise on HR and characteristics of beluga respiration at frequencies overlaying the zone of best hearing [7].

The study was conducted on a young male beluga (weight, 195 kg; length, 240 cm) at the Utrish Marine Station of the Severtsov Institute of Ecology and Evolution. The animal was captured two month before the beginning of research.

During the experiment, the beluga was placed onto a stretcher and transferred to a bath containing seawater (4 × 0.8 × 0.8 m). A total of 20 experiments with a duration of 2–4.5 h each were conducted. An emitter was used to present band-pass acoustic noises that differed in frequency (19–27, 27–38, 38–54, 54–78, and 78–108 kHz), intensity (140, 150, and 160 dB), and duration (1, 3, and 10 min) to the beluga. During one day, from 1 to 6 noises (on average, 4 noises per day) were presented; more often (16 out of 20 cases), the noises were of one frequency and growing duration. Recording of electrocardiogram (ECG) was conducted by means of a polygraph using two suction cup disk electrodes. Instantaneous HR was assessed as inverse values of time intervals between two consecutive heartbeats and were averaged over 1-min time intervals. The average HR in a 4- to 5-min interval before noise (control) was compared to the HR during the presentation of noise (in 1-min intervals or throughout the presentation of noise), as well as after the end of noise. The time of respiratory acts was identified using video recording and time-synchronized with ECG.

The HR of the beluga laying on the stretcher was characterized by expressed arrhythmia: periods of bradycardia, which accounted for the phase of breath holding (respiration pauses longer than 60 s) alternated with periods of tachycardia, which coincided with a series of respiration acts (2–10 inspirations over 30-s intervals; Fig. 1). The minimal instantaneous HR during breath holding decreased to 20 beats/min. The maximal HR during the series of breaths reached 85 beats/min. The average HR in different experiments varied from 41 to 63 beats/min (during 5-min time intervals). Thus, the respiration and HR characteristics of the beluga lying on the stretcher were comparable to those of a beluga kept in a pool [8, 9].

Simultaneously with the beginning of noise, the HR of the beluga increased dramatically; i.e., manifest tachycardia that lasted for several minutes developed (Fig. 1, noises *A* and *B*). The instantaneous HR reached the maximal values together with the beginning of noise and then increased to 100 beats/min (approximately 15 beats/min more than under the control conditions); after that, it gradually decreased. Sometimes, during 10-min noise, tachycardia was replaced by bradycardia. The minimal values of instantaneous HR

[a] *Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, Leninskii pr. 33, Moscow, 117091 Russia*

[b] *OOO Utrish Dolphinarium, Leninskii pr. 33, Moscow, 117091 Russia*

[c] *University of California at Los Angeles, CA 90095, United States*

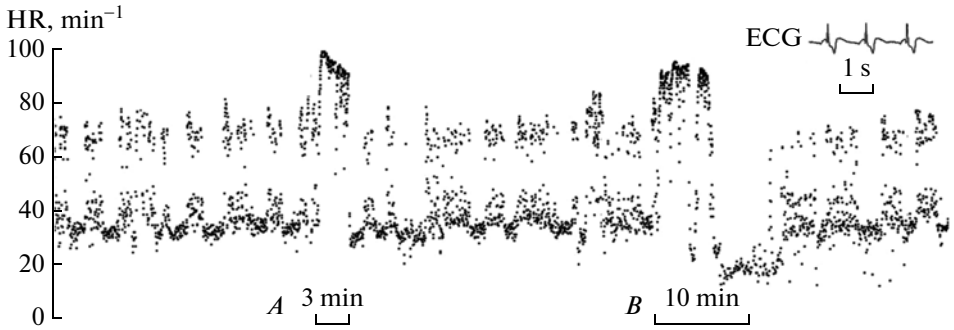


Fig. 1. HR in a beluga before acoustic noise. Each point is an instantaneous HR at a certain moment (beats/min). *A* and *B*, time intervals of presentation with a duration of 3 and 10 min, respectively. Frequency, 19–27 kHz; intensity, 150 dB. In the upper corner a fragment of ECG is shown.

in such periods were 12 beats/min, i.e., lower than under the control conditions. The average HR in the first minute of noise with an intensity of 150 dB did not depend on the order of noise presentation in the experiment (one-way ANOVA with repetitions, $p > 0.05$; $F[3.18] = 1.98$). Thus, no habituation of beluga to noise occurred; this allowed us to conduct statistical treatment without taking into account the order of noise presentation in the experiment.

Acoustic noise with a duration of 1 min and intensity of 150 dB was accompanied by a sharp increase in the average HR during the time of noise action at all frequencies ($p < 0.03$ for all frequencies, paired *t* test). At the first minute of noise HR grew up to 208% of control values (Fig. 2). And degree of acceleration of HR of beluga with high reliability depended on frequency of acoustic noise (ANOVA, $p = 0.02$; $F[4.35] = 3.21$). With an increase in noise frequency, the excess of average HR over the control decreased (from 178 to 140% of the values in the control period). The expression of tachycardia during noise at frequencies of 19–27 kHz was much higher than at frequencies 54–78 and 78–108 kHz (paired comparison, $p < 0.05$).

Tachycardia caused in the beluga by noise of the lowest frequency (19–27 kHz) was approximately at the same level for no less than 3 min, because average values of HR assessed for one- and three-day intervals did not differ ($p > 0.05$; *t* test). When the frequency of 3 min noise increased from 19 to 54 kHz, the average HR during the noise also significantly decreased ($p < 0.01$; $F[4.25] = 5.15$). Growth of HR at noise of 19–27 kHz was much bigger than at frequencies greater than 38 kHz ($p < 0.05$, pairwise comparison). Average values of HR at noise action for 3 min were higher than in control period ($p < 0.05$; paired *t* test) for all frequencies except for 54–78 kHz (noise was presented only 3 times).

During 10-min noise with a frequency of 19–27 kHz, the average HR was also greater than the control values ($p < 0.05$, *t* test; Fig. 2) and was 140%. At higher frequencies of noise, the increase in the HR did not exceed 10% in comparison with the control period ($p > 0.05$). More detailed analysis indicated that tachycardia caused by noise with a frequency of 19–27 kHz differed significantly from control values during no less than 4 min ($p < 0.05$, pairwise comparison; after ANOVA with repetitions, $p < 0.01$, $F[10.44] = 8.27$). During noise with a frequency of 27–38, 38–54, or 54–108 kHz, the increase of HR above background values was significant only during the first 1-min interval ($p < 0.05$). Thus, the intensity and duration of tachycardia that developed in the beluga upon presentation of acoustic noise with a duration of 1, 3, and 10 min with frequencies from 19 to 108 kHz depended on noise frequencies and were maximal at frequencies of 19–27 kHz. The response decreased with the growth of noise frequency.

After the end of noise, HR decreased. Based on the data, we may assess the dependence of HR changes after cessation of noise with a frequency of 27–38 kHz and durations of 1 and 10 min. The average HR during a 5-min interval after the end of noise with a duration of 1 min (5 presentations) was less (44 ± 3 beats/min) than in the control period of the same duration (56 ± 3 beats/min; 78% compared to the control period; $p < 0.001$, after ANOVA with repetitions; $F[2.8] = 73.97$; $p < 0.001$). Differences in the average HR during 5-min intervals were determined first of all by the sharp decrease in HR in the first minute after the end of noise (on average, 58% compared to the control period; $p < 0.05$; after ANOVA with repetitions, $F[4.20] = 5.10$; $p = 0.001$). After the end of noise with a duration of 10 min (in total, 5 presentations), HR in the first minute was also lower (by 45%; Fig. 3) than in the control period ($p < 0.05$; after ANOVA with repetitions, $p < 0.001$, $F[4.20] = 7.74$). Thus, not only the beginning, but also the termination of acoustic noise was accompanied by changes in the HR in beluga, and the direction of changes were the opposite (increase and decrease, respectively).

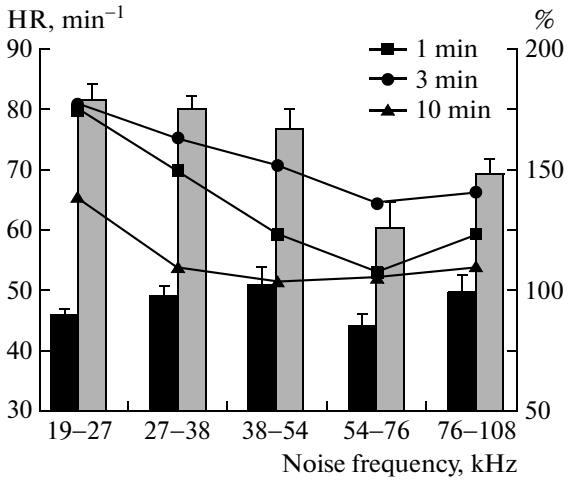


Fig. 2. HR in a beluga before and during presentation of acoustic noise with a duration of 1, 3, and 10 min at different noise frequencies. Dark and light columns show HR (beats/min) in 5-min intervals before and after action of noise with a duration of 1 min, respectively. The lines connect values of relative HR during the presentation of noise of different frequency with durations of 1, 3, and 10 min (in percent of the HR before presentation of noise). Noise intensity, 150 dB.

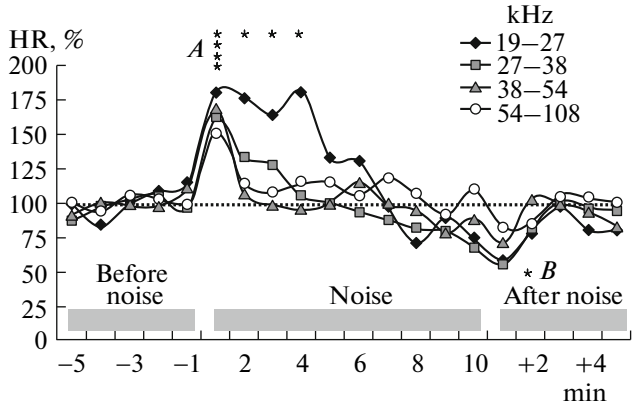


Fig. 3. HR in a beluga before, during and after presentation of acoustic noise with a duration of 10 min at different noise frequencies. The abscissa shows 1-min time interval. The lines connect the values of relative HR during noise with frequencies of 19–27, 27–38, 38–54 kHz, as well as 54–78 and 78–108 kHz (in percent of the HR before presentation of noise). *A*: *—statistically significant differences ($p < 0.05$) between HR in 1-min intervals during noise of different frequencies (top-down: 19–27, 27–38, 38–54 kHz as well as 54–78 and 78–108 kHz) from HR before presentation of noise (averaged over 5 min). *B*: *—statistically significant differences ($p < 0.05$) between HR in the first 1-min interval after the end of noise and HR before presentation of noise. Noise frequency, 27–38 kHz.

In this study, noises with intensities of 150 dB and, rarely 160 and 140 dB were presented to the beluga. Taking into account that HR during 1 min of noise with an intensity of 150 dB at frequencies of 19–27 (178 ± 6% of the HR in the control, $n = 5$) and 27–38 kHz (164 ± 7%, $n = 14$; $p < 0.15$, t test) did not differ, we analyzed the dependence of HR change in the beluga on the noise intensity by pooling the data obtained upon presentation of the noises of these two frequencies. According to expectations, the intensity of tachycardia in the beluga depended on the noise intensity ($p < 0.01$, $F[2.28] = 5.41$). The average HR at a noise intensity of 140 dB (123 ± 7%, $n = 4$) was much less than at intensities of 150 dB (167 ± 5%, $n = 19$) and 160 dB (168 ± 12, $n = 8$; $p < 0.05$, pairwise comparison). Thus, the degree of tachycardia caused by acoustic noise in the beluga increased with the growth of noise intensity from 140 to 150 dB.

The changes in the respiration pattern during noise presentation were much less than the changes in the HR and were confined to the first minute of noise (table). For example, during the first minute of 3-min noise with frequencies of 19–27 and 27–38 kHz, which caused the greatest enhancement of HR, the average duration of the respiration pause (RP) decreased and was 72 and 60% of the average RP during the control period (4 min before noise), respectively. However, considering the degree of variability of RP in the beluga, these differences were statistically nonsignificant ($p > 0.05$). On the other hand, upon presentation of noise with a frequency of 76–108 kHz, which caused the minimal change in HR, the RP became even shorter (39% of the control values; $p < 0.05$; after rank-order ANOVA, paired comparison, $p < 0.05$). Finally, noise with a frequency of 38–54 kHz did not result in change of respiration. Respiration pauses of the beluga during the second and third minutes of noise were practically the same as before the beginning of the noise. Thus, respiration rate of the beluga upon presentation of loud acoustic noise increased. These changes lasted for no more than 1 min and were not directly associated with the changes in HR.

This is the first study on the response of the cardiovascular system of a beluga to prolonged intense acoustic noise with a frequency overlapping the zone of best hearing [7]. The response of the beluga to noise consisted in an increase in the HR, which depended on the frequency and intensity of noise. Acceleration of HR in the beluga in response to noise is the first component of the "acoustic startle response" to sudden presentation of a strong sound stimulus thoroughly studied on humans and land mammals. The intensity of tachycardia indicates the interaction of different branches of autonomic nervous system: activation of the sympathetic systems and suppression of the parasympathetic systems [10]. Upon changes in common environmental conditions, HR may increase by 60% compared to control values [2, 3]. Tachycardia is considered a cardiovascular component of the stress

Average duration of respiration pause in a beluga before and during presentation of 3-min acoustic noise of different frequencies

Noise frequency (kHz)	Number of presentations	RP_{av}, s			
		before noise (control)	minute from the beginning of noise		
			1	2	3
19–27	4	20 ± 3 (7–76)	13 ± 1 (8–19)	19 ± 2 (12–30)	30 ± 14 (9–182)
27–38	9	23 ± 2 (7–67)	18 ± 3 (8–41)	39 ± 10 (12–109)	46 ± 17 (5–208)
38–54	7	23 ± 2 (7–95)	25 ± 4 (7–77)	63 ± 28 (9–163)	32 ± 7 (9–59)
54–78	3	25 ± 5 (5–66)	14 ± 1 (6–19)	23 ± 1 (9–35)	24 ± 6 (17–36)
78–108	6	30 ± 2 (12–106)	13 ± 1* (8–28)	26 ± 5 (11–84)	27 ± 5 (15–48)

Note: RP in the control is the average over 4 min for all presentations; during noise, the average per minute before noise. In parenthesis, the minimal and maximal values of RP during all presentations are given. The asterisk indicate a significant difference from the control (one-way ANOVA, $p < 0.01$, rank-order pairwise comparison, $p < 0.05$). Noise intensity is 150 dB.

reaction, indicator of animal defense reaction and level of "social" stress [11]. Much less expressed (only several percent) and short lasting (up to 30 s) acceleration of HR is observed in animals in response to sound stimuli that have emotional meanings of danger (calls of dominant males in primates [12]; sounds of jaw clap treat in dolphins [6]).

In was shown that presentation to a bottlenose dolphin of acoustic noise with a frequency from 4 to 11 kHz resulted in temporary shifts in hearing thresholds at an intensity of more than 179 dB [13]. Our data indicate that severe tachycardia developed in the beluga at lower noise intensities (as low as 140 dB); at higher intensities, the HR could reach a twofold excess over the control values and last for no less than 4 min. The changes in the respiration parameters in the beluga during noise with a duration of up to 10 min were smaller and lasted for less than 1 min. To summarize, HR may serve as a criterion of physiological response (state) to acoustic noises, including anthropogenic, in belugas and, most likely, in other cetaceans.

ACKNOWLEDGMENTS

The study was conducted in the framework of the "Program of Study of Distribution and Migration of Belugas" of the permanent expedition of the Russian Academy of Sciences and supported by the Russian Geographic Society.

REFERENCES

1. Southal, B.L., Bowles, A.E., Ellison, W.T., et al., *Aquat. Mammals*, 2007, vol. 33, pp. 1–521.
2. Aschwanden, J., Gygax, L., Wechsler, B., et al., *Physiol. Behav.,* 2008, vol. 95, pp. 641–648.
3. Fallani, G., Prato, E.P., and Valsecchi, P., *Physiol. Behav.*, 2007, vol. 90, pp. 648–655.
4. Van der Staay, F.J., Joosse, M., van Dijk, H., et al., *BMC Vet. Res.*, 2011, vol. 7, pp. 1–29.
5. Holand, S., Girard, A., Laude, D., et al., *J. Hypertens.*, 1999, vol. 17, pp. 1893–1897.
6. Miksis, J.L., Grund, M.D., Nowacek, D.P., et al., *J. Comp. Psychol.,* 2001, vol. 115, pp. 227–232.
7. Supin, A.Y., Popov, V.V., and Mass, A.M., *The Sensory Physiology of Aquatic Mammals*, Boston: Kluwer Acad, 2001.
8. Lyamin, O.I., Sigal, Dzh.M., and Mukhametov, L.M., in *Morskie mlekopitayushchie Golarktiki* (Marine Mammals of the Holarctic), Kaliningrad, 2010, pp. 352–358.
9. Shpak, O.V., Lyamin, O.I., and Mukhametov, L.M., *Estestv. Tekhn. Nauki*, 2008, vol. 2, pp. 149–153.
10. Vila, J., Guerra, P., and Munoz, M.A.L., et al., *Int. J. Psych.*, 2007, vol. 66, pp. 169–182.
11. Herd, J.A., *Physiol. Rev.*, 1991, vol. 71, pp. 305–330.
12. Berntson, G.G. and Boysen, S.T., *Behav. Neurosci.*, 1989, vol. 103, pp. 235–245.
13. Nachtigall, P.E., Pawloski, J.L., and Au, W.W.L., *J. Acoust. Soc. Am.*, 2003, vol. 113, pp. 3425–3429.

ITP Goldstein <itp.goldstein@noaa.gov>

seismic testing

Molly Mccabe <mollykmccabe@yahoo.com> Wed, Sep 19, 2012 at 6:20 PM
Reply-To: Molly Mccabe <mollykmccabe@yahoo.com>
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>

Dear NMFS,
Im sure you are hearing a lot of complaints about the seismic testing that is going to happen soon. I beg of you to not let it happen. This is killing OUR wildlife, one main reason why we all live here close to the bay, and we all know that there are other methods. We love our wildlife and will do anything to protect it, I hope you can do the same. Thank you.
-Molly McCabe

ITP Goldstein <itp.goldstein@noaa.gov>

Dolphin harassment.

Nan Barnard-Jorgensen <mimisisibibijibi@mac.com> Fri, Oct 5, 2012 at 4:27 AM
To: ITP.Goldstein@noaa.gov

To whom it may concern:

I am outraged! Dolphins and porpoises— some of the most beautiful and clever creatures on the planet — harassed and harried, harmed by a dim witted power company?

No ! Infamy!! STOP THIS!

Sincerely,

NAN JØRGENSEN
Independent Filmmaker
mimisisibibijibi@mac.com

ITP Goldstein <itp.goldstein@noaa.gov>

please dont take wrong decisions!

Nicolás Cáceres Tornel <nicolascaceresarquitecto@gmail.com> Mon, Oct 15, 2012 at 1:27 AM
To: ITP.Goldstein@noaa.gov

PLEASE DONT KILL MARINE MAMALS! TAKE CARE OF OUR SEAS! THINK ABOUT THE LEGACY TO YOUR CHILDREN!

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

daily special <flatheadstick@gmail.com> Sun, Oct 14, 2012 at 10:11 PM
To: ITP.Goldstein@noaa.gov

To: P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service.

I write today to say that the danger and devastation caused by PG&E's seismic testing needs to be stopped . Why should we employ and allow such devastating horror to be released upon our majestic marine mammals. I request that NMF's uphold and enforce the marine mammal protection act of 1972 and deny PG&e 's request for seismic testing in our oceans. This is the time to educate and explore new technologies that does not leave behind a harmful wake of destruction. This testing does not benefit the public and simply is not worth the costs.
here are some concerns
1. Proposal downplays the potential effect on marine life including fish, invertebrates and marine mammals.

2. Important studies that linked seismic surveys to strandings are not mentioned in proposal. Specifically the report by Gentry (2000) called "**Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000**" is not mentioned, let alone discussed in detail. Report by Malakoff 2002 called **"Suit ties whale deaths to research cruise"** only mentioned briefly without significant discussion. Other occurrences such as Madagascar stranding are not mentioned at all.

These are documented cases that have not been mentioned in proposal (read more detailed description in our previous **post**):

1. Mozambique 2006,

2. Gulf of California, 2002

3. Galapagos Islands, 2000

4. Madagascar, 2008

5. Peru, 2012

6. Interesting Statistics from Australia (2002-2004)

3. Crucial study that showed cardiorespiratory changes in beluga whale in response to acoustic noise is not even mentioned in proposal (**link**). In this study belugas were exposed to noise at much lower level than is planned in California and the animal demonstrated severe tachycardia "at lower noise intensities (as low as 140 dB);"

4. This proposal is rushed and the levels of impact are not investigated enough and not accessed based on the best scientific evidence available.

5. The company's planned actions lack transparency, they should be required to fully and publicly disclose where activities take place, what equipment will be used, exact Sound Pressure Levels, when activities will take place. Additionally, marine mammal observers logs where they record all marine mammal sightings should be publicly available.

6. The proposal lacks specifics of how strandings will be investigated. It does not include what protocol of

stranding investigation will be, what independent organizations will investigate strandings, who and in what manner will look for the evidence of acoustic trauma, decompression sickness related embolism, hemorrhage, etc.

7. NMFS should deny the permit based on omission of the best scientific evidence available and inadequate assessment of impact on marine life.

Sincerely

Ninette Jones

7637 N. Interstate

Portland Oregon 97217

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Olivia Lim <olivialim.us@gmail.com> Sun, Oct 14, 2012 at 8:53 PM
To: ITP.Goldstein@noaa.gov

To P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service,

I ask that you prevent the seismic testing off the coast of California, as it will adversely affect marine life, particularly those species that depend on sonic waves to sense their surroundings and communicate. The environmental impact of the seismic testing has not been done well. Other studies have shown that the beluga whale's cardiorespiratory functions can degraded because of acoustic noise, even at low levels of intensity. Therefore I ask that you deny the requested permit for seismic testing.

Thank you for reading this,
Olivia Lim

ITP Goldstein <itp.goldstein@noaa.gov>

URGENT

ophelia marcal <contact@opheliamarcal.com> Sun, Oct 14, 2012 at 6:34 PM
To: ITP.Goldstein@noaa.gov

PLEASE!!!!!!

STOP KILLLING MARINE MAMMALS

Please

Ophelia Marçal

Potugal

_____ Information from ESET NOD32 Antivirus, version of virus signature database 7584 (20121014)
_____

The message was checked by ESET NOD32 Antivirus.

http://www.eset.com

ITP Goldstein <itp.goldstein@noaa.gov>

Seismic Survey

Paige Kosturi <paigekosturi@rocketmail.com> Sun, Oct 14, 2012 at 4:05 PM
Reply-To: Paige Kosturi <paigekosturi@rocketmail.com>
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>

I oppose any seismic testing that endangers our Oceans and Marine Mammals. I see no inclusion of studies conducted of beached whales and dolphins due to seismic activity. This is important. Any evidence of this Must be included and taken into consideration. These Mammals run on Sonar and loud blasts deafen them making it impossible to find food and migrate. Therefore they beach themselves with no choice. We are killing our oceans! Please stop this destructive action. Thank you for your time and consideration.

ITP Goldstein <itp.goldstein@noaa.gov>

Seismic Survey

Paige Kosturi <paigekosturi@rocketmail.com> Sun, Oct 14, 2012 at 4:05 PM
Reply-To: Paige Kosturi <paigekosturi@rocketmail.com>
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>

I oppose any seismic testing that endangers our Oceans and Marine Mammals. I see no inclusion of studies conducted of beached whales and dolphins due to seismic activity. This is important. Any evidence of this Must be included and taken into consideration. These Mammals run on Sonar and loud blasts deafen them making it impossible to find food and migrate. Therefore they beach themselves with no choice. We are killing our oceans! Please stop this destructive action. Thank you for your time and consideration.

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Pamela Jackson <pamsj15@gmail.com> Sun, Oct 14, 2012 at 11:08 PM
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>

P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service.

My concerns:

1. Proposal downplays the potential effect on marine life including fish, invertebrates and marine mammals.

2. Important studies that linked seismic surveys to strandings are not mentioned in proposal. Specifically the report by Gentry (2000) called "**Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000**" is not mentioned, let alone discussed in detail. Report by Malakoff 2002 called **"Suit ties whale deaths to research cruise"** only mentioned briefly without significant discussion. Other occurrences such as Madagascar stranding are not mentioned at all.

These are documented cases that have not been mentioned in proposal (read more detailed description in our previous **post**):

1. Mozambique 2006,

2. Gulf of California, 2002

3. Galapagos Islands, 2000

4. Madagascar, 2008

5. Peru, 2012

6. Interesting Statistics from Australia (2002-2004)

3. Crucial study that showed cardiorespiratory changes in beluga whale in response to acoustic noise is not even mentioned in proposal (**link**). In this study belugas were exposed to noise at much lower level than is planned in California and the animal demonstrated severe tachycardia "at lower noise intensities (as low as 140 dB);"

4. This proposal is rushed and the levels of impact are not investigated enough and not accessed based on the best scientific evidence available.

5. The company's planned actions lack transparency, they should be required to fully and publicly disclose where activities take place, what equipment will be used, exact Sound Pressure Levels, when activities will take place. Additionally, marine mammal observers logs where they record all marine mammal sightings should be publicly available.

6. The proposal lacks specifics of how strandings will be investigated. It does not include what protocol of stranding investigation will be, what independent organizations will investigate strandings, who and in what manner will look for the evidence of acoustic trauma, decompression sickness related embolism, hemorrhage, etc.

7. NMFS should deny the permit based on omission of the best scientific evidence available and inadequate assessment of impact on marine life.

Feel free to add to these point anything you would like. You might also want read our previous blog post on dangers of seismic testing here (**link**)

Please do not let the seismic testing happen as this shameful act is so detrimental to so many forms of life.

There are too many variables that have not yet been considered. The impacts will be devastating.

Stop this from moving forward now!

Sincerely,

Pam Jack

321 Camino San Clemente

San Clemente, CA 92672

Sent from my iPhone

ITP Goldstein <itp.goldstein@noaa.gov>

(no subject)

paul mitchell <pcmitchell64@att.net> Sat, Oct 6, 2012 at 9:40 PM
To: itp.goldstein@noaa.gov

Dear Commissioners:

I'm writing to express my opposition to PG&E's Proposal for Seismic Testing in Central Coast.

This project could have dangerous impacts on ocean ecosystems and recreational ocean users.

PG&E's own EIR clearly states unavoidable impacts to marine life. As an ocean enthusiast, I'm deeply concerned about the impacts to marine life during the testing. California is known for its rich ocean waters and we need to protect every level of our ocean ecosystem from risky and arguably unnecessary projects, such as seismic testing.

I'm also concerned that PG&E is disregarding the health and safety of ocean users. Their EIR clearly says the proposed activities would expose persons present in the water to harmful noise levels. And a recent PG&E map shows that dB levels could reach upward of 160 at some beaches. This is well over the threshold for human safety.

Finally, I'm concerned that PG&E is not analyzing decades of data collected by several sources to paint a full picture of geologic hazards near the power plant, new testing will only provide marginal improvement to what is already known.

Please deny this project. The Coastal Act was created to protect ocean resources and recreation. We believe this project does not conform to following sections of the Coastal Act:

**Section 30220--Protection of certain water-oriented activities-- Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas shall be protected for such uses.

**Section 30224--Recreational boating use--Increased recreational boating use of coastal waters shall be encouraged…

**Section 30230-- Marine resources; maintenance
Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.

**Section 30210-- Access; recreational opportunities; posting
In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs...
We urge you to deny this project and send PG&E "back to the drawing board" in order to protect marine life and ocean users from this unnecessary project.

Thank you in advance for your thoughtful consideration.
Sincerely,

Paul and Carolyn Mitchell

ITP Goldstein <itp.goldstein@noaa.gov>

PLease Stop the seismic testing off the California coastline.

Paul <paul@bodyandbalancecenter.com> Tue, Oct 16, 2012 at 9:10 AM
To: ITP.Goldstein@noaa.gov

To: P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service.

I would like you to please stop the seismic testing off the central coast of california in order to protect marine mammals and other sea species which may be effected by this.

Paul Teixeira

Port San Luis Commercial Fishermens Association (PSLCFA) Comments on Proposed High Energy Seismic Survey (HESS) off OUR coast

To, NOAA, NMFS

Hello, Thanks you for excepting these comments and I hope you weigh them in when making your decision on the HESS Permit that is before you now. My name is Brian Stacy I am A lifelong resident of Morro Bay (47yrs) I am a 24 year local fisherman I started My career in the shallow water fishery now known as the "Nearshore fishery". I am the current V.P. of PSLCFA, And the past 13 months have been one of the main reps in regard to the unproductive, "NON negotiations" with PG&E in regard to HESS for fisheries displacement and resource damage mitigation. I have been frustrated by PG&Es failure to negotiate in good faith. And have been enlightened about the destructive nature of HESS as we new nothing about 250 DB seismic surveys prior.

We OPPOSE these tests being permitted and conducted and have joined the C.O.A.S.T.. ALLIANCE AND SUPPORT THEIR EFFORT TO STOP HIGH ENERGY SEISMIC SURVEYS HERE.

I will share my experience and knowledge learned through a year and a half of wasted time dealing with this due to PG&E proposing this project, and their unethical buisness practices. All of which was paid for by us as PG&E refuses to even reimburse the associations for legal and consulting fees incured in our review of THEIR project. Not to mention all of our time off work, gas to unproductive meetings, time to prepare and participate in a bogus process were their only intention seems to have been to stall us to this point. Among other expensise all because they proposed this project, that was not mandated by AB 1632 as some might have you believe.. I feel my experience is relavent in your deliberations in regard to this project and any authority or influence you may have to deny a permit or advise others to do so. It should provide you enough insight to understand why they should not be permitted to do HESS at this time or Hopefully ever and why they should not have already been allowed to do LESS (low energy seismic surveys).

I will first touch on LESS and the problems with it as it did not go through a CEQA process as it should of and there was no EIR or current MND to go with this project that was conducted around protected areas like the RCA, MPA and under the MLPA. None of which are reffrenced in the environmental document they (PG&Es contractor Fugro) were allowed to use under the CSLC outdated Geophisical Survey Permit Program (GSPP). there was also no mention of current fisheries we utilize like hagfish and nearshore the ones that were directly impacted by LESS Although totally inappropriate and outdated they did not even comply with the mitigation measures outlined in the 1984 MND 358 and GSPP that CSLC issued their "umbrella" permit

under. Further CSLC refused to except complaints on or do monitoring after complaints were made, or enforcement any of the inappropriate mitigation measures that were outlined in the two outdated documents, And they refuse to recognize the update, "guidelines to reduce conflicts between "geophisical surveys and fishermen", that was produced by Fishermen and oil companies in 1989 through the "Joint Oil Fisheries Liason Committee" in response to problems that had arisen after the 1984 program was introduced and implimented. This is all relavent because you are reviewing a document The HESS EIR that was produced by the same entity and full of inadequacies and unmitigated impacts. I thought you might like to know of the LESS situation in regard to CSLC and the project applicant, as I made Both aware of the problems, and view your recommendation on HESS to CCC through it.

The problems that arose from this what I believe to be Illegal survey due to our rights under CEQA not having been provided to us by CSLC Staff are as follows. First to my area the Nearshore fish suffered from mortality issues (abnormal amount dying in the tank) and the catch was down by 50% in port san luis, and there was behavioral issues as well alot were found to be weak. The halibut trawlers catch dropped off to near nothing the Hagfish fishermen were displaced as well and their catch was down 50% too. All of this happened after LESS showed up unannounced. There was displacement of fishing effort by the survey vessel and noise issues as far as catching fish. The whales and bait left after the last LESS showed up unannounced creating a tourism impact to avila and the harbor and there were others as well i am too slow of typer to outline here. None of these were Identified before they happened or mitigated after. Had we been provided our due process under CEQA we would have fought for all of these to be fully addressed, studied and mitigated as needed. Alongside other california residents.

As far as the fishermen I represent go I registered a complaint with the HESS applicant PG&E and they said "it was not their permit" But that they were "prepared to compensate the displacement of fishermen" only. They gave me a "refrigerator claim form" (fridge form) the type they give out if the power goes out and there is "food spoilage". They also said they were going to pay the claims which they later rejected after stalling until that survey was over. And they had told me to pass them out to effected fishermen and I did. I indicated to them it was not a "fishing type of claim form" and that we should have had meetings and negotiated a process for claims, and forms qualifying criteria ect.and asked where they prepared to do that now? they refused to discuss it as it was not their permit they said. I asked "how did your contractor get a permit without us having a chance to review and comment and negotiate for fair mitigation for my fishermen and to identify impacts on our resources and get agreements in place to mitigate all the above. They indicated talk to FUGRO it is their permit. This all happened after 12-4-11 when the unannounced 20 day LESS began. and the hell that has been my life since was put upon me by PG&E the project applicant. This all happened on the heels of HESS negotiations beginning and we have achieved nothing in regard to those . this story is long

and sad as it has taken over the place that used to be my life~! I have many email exchanges if you need to see how pathetic PG&Es treatment of the fishermen they displace with their surveys and their utter disregard for our rights as established buisnesses and our permits to catch fish and right to make a living. And the same can be said for their concern for the resource they will further disrupt should HESS be permitted and allowed to be conducted in the same general area which I really hope it is not.

Beyond the CEQA violations and the failure to enforce mitigation measures the fishery related issues the overall resource issues, the compliance issues the data poor issues the failure to address MLPA, MPA, RCA issues the no compensation issues the no agreements issues the noise related issues the NO CURRENT ENVIRONMENTAL ASSESMENT OR DOCUMENT pertinant in todays regulatory environment issues The applicable fisheries issues there lies and this goes back to our rights to review in a situation like this under CEQA the no baseline data issue.

As fishermen we have a pretty good knowledge of our local ocean resources and how they could be effected by different events that happen in the ocean environment, from a "EL NINO" event to what our concerns would be with a "LESS" and most things in between. My personnel feeling about the worst thing from the LESS being conducted without review is that we lost a golden oppertunity to collect data prior to these I believe Illegal surveys beginning. As we did with HESS we the fishermen would have called for a current baseline of data to be gathered so we could identify impacts after the LESS. now I see that could have been applied to the HESS as well. The LESS has already had impacts on the resources we may never be able to know for sure what they are. Derel reffrenced the dead dolphin thing and I was told they did not do mammal monitoring at all .so we do not know what kind of harrasment the whales and dolphins may have had bestowed on them or if they were injured or killed as with no mammal monitoring as outlined in that old mnd they used we will never know.

I think the main points I want to make are the Lack of regard for OUR CEQA rights, potential impacts to the resource, the fishermen and our families, by CSLC staff that told me last week was because "they are to broke to provide public process and produce a new environmental document for LESS". I have no idea why they should have to with old PG&Es contractor applying. And. they also refused to allow a complaint on my second attempt as well and refused to do any enforcement too. they indicated the contractor Fugro had "complied with all mitigation measures" because they said "fugro told us they had" even though I was offering evidence to the opposite they refused to take a complait or do anything at all. They did say that currently PG&E is working on a new MND for LESS so maybe I accomplished something. But it makes you wander "why not before they began LESS"? I neglected to mention that Richard Greenwood the CSLC staff member in charge of these surveys was unable to produce a copy of mnd 358 or the GSPP that he was giving permits out based on when I requested it and I had to

get it elsewere in CSLC and it was not on the websight either. and is the guy I made 2 formal complaints to on LESS that took NO action and refused to either take a complaint or monitor for compliance after I MADE THE FIRST ONE ONLY ALLOWED THEM TO GO ON. This is the people that developed the inadequate EIR that is lacking in so many areas that you are preparing to make a decision based on. Has anyone seen the section on the western grey whale?

Lessons learned through this process: or lack thereof:

1. PG&E cannot be trusted. not with a valuable resource like our central CA. ocean. They can not be trusted to compensate effected buisnesses and municipalities or anybody impacted by their operations anywhere look at the poor folks in San Bruno and others.

2. CSLC will overlook any violation and do not understand the words mitigation, enforcement, monitoring,. compliance,, complaint, process, and a few others or CEQA either. If we would have had a time machine maybe but shy of that we had no way or oppertunity to comment. And the current EIR for HESS would need a substantial upgrade to be inadequate I was being kind.!

I have others but I would seem like I resent this HESS process and LESS issues eating up so much of my life because I volunteered to be abused by PG&E when I first allowed myself to be elected "Nearshore fishermens representative" And later when I allowed myself to be elected V.P. of PSLCFA and become lead on this Issue to protect my fellow fishermen and for us to try to stop this kind of thing from happening with HESS should regulators not do the right thing and deny the permit and reject this destructive and intrusive unmandated project.

Thank You for your time and conscideration in regard to this matter. Should anyone want anything like email chaiin a copy of the fridge form ect. I am includeing a couple in regard to the complaints to CSLC and the lie by PG&E about paying the clams and i may see others that i should send too!

Brian Stacy Vice President Port San Luis Commercial Fishermens Association

PSLCFA is A member of the C.O.A.S.T. Alliance and supports their efforts to stop permitting of this project and the project itself for the sake of our local resources!

ITP Goldstein <itp.goldstein@noaa.gov>

letter to support cessation of planned acoustic seismic testing of the California coast, November 2012

Rachel Duchak <rad@ccfoodie.com> Tue, Oct 16, 2012 at 3:00 AM
To: ITP.Goldstein@noaa.gov

Thanks for reading our letters and helping us stop this destructive plan.

Sincerely,

Rachel Duchak

Rachel Duchak
805/234-6331
CentralCoastFoodie.com • CCFoodie.com

Central Coast Foodie
549 Lilac Drive
Los Osos, CA 93401

Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

Dear Mr. Payne: October 15, 2012

I am writing to urge you to help us stop an impending disaster in the waters off California's Central Coast in November 2012 that will drastically affect human and marine life alike. Although acoustic seismic testing is not mandated in the legislation that requires PG&E to explore the nature of the faults that lie underwater off the coast of Diablo Canyon Nuclear Power Plant, this corporation with a bad safety record (see: San Bruno explosion) appears hell-bent on imposing the colossal impact of blasting 250 decibels into the ocean hour after hour for weeks at a time. Are they demonstrating a sudden interest in our personal safety or are they hoping to collect enough data about the oil reserves along our protected coastline to help their friends in the fossil fuel industry? Their craving for oil is not as strong as our

determination to protect our ocean.

Please help us protect our marine neighbors and our vulnerable fishing and hospitality industries. Despite PG&E's efforts to minimize concerns while attempting to steamroll this invasive testing program over the objections of extremely concerned local citizens, we're already seeing the effects of the "low-energy testing" they've been initiating over the last month. Surfers, fishermen, birdwatchers and others who spend a great deal of time on the ocean and along our shores have already reported disturbing sights: long-time fishermen report catching fish they've never seen before, another frequent sailor reported that he saw a whale he'd never seen before--and he has spent a great deal of time on this section of the Pacific Ocean. The animals already are experiencing distress from this "low energy" acoustic testing—distressed pelicans, dead dolphins, and large numbers of fish demonstrating bizarre behavior that reflects their distress from this preliminary testing. Imagine the terrible impact once PG&E starts testing at full levels: Sea Otters, California Gray Whales, Orcas, Rockfish and so many other sensitive, protected marine species will be destroyed—not harassed but destroyed—if this type of invasive acoustic testing is allowed to proceed.

Time is so short and PG&E is so intent to push concerned citizens out of the way for this unnecessary testing. It sure looks like they want to survey for oil at all costs and they don't care who will be destroyed along the way. Certainly, no one in the Central Coast wants this nuclear power plant on a fault line to giggle into a Fukushima, but this invasive testing—which is all about oil while ignoring the human and non-human costs—is not the answer. There are other ways to collect the data that must be recorded to

—Duchak, page 2

understand the seismic risks to this facility. This testing should focus on safety for those of us on shore and those swimming through the ocean not on generating a sneak peek of oil reserve data in the midst of severe carnage from this terrible acoustic seismic testing program.

Please help us to stop this destructive, short-sighted plan so we can save our beautiful, protected Central Coast and Marine Protected Areas. Fishermen haven't been able to drop a hook in these MPAs for years as the populations have recovered. Why squander this improvement to the ocean's health just because a wealthy corporation wants to make more and ever more money? This is a bad trade.

Thank you for reading our letters and taking our concerns to heart. We love the ocean as much as you all do and are determined to see these protected areas and sensitive communities preserved and protected. If you wish to hear more stories of how this "low-energy testing" is already impacting vulnerable animal populations, please feel free to contact me at 805/234-6331 or rad@ccfoodie.com. Please help us.

Sincerely,

Rachel Duchak, Principal
CentralCoastFoodie.com

NOAA_letter_OceanBlasting.pdf
43K

Central Coast Foodie
549 Lilac Drive
Los Osos, CA 93401

Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

Dear Mr. Payne: October 15, 2012

I am writing to urge you to help us stop an impending disaster in the waters off California's Central Coast in November 2012 that will drastically affect human and marine life alike. Although acoustic seismic testing is not mandated in the legislation that requires PG&E to explore the nature of the faults that lie underwater off the coast of Diablo Canyon Nuclear Power Plant, this corporation with a bad safety record (see: San Bruno explosion) appears hell-bent on imposing the colossal impact of blasting 250 decibels into the ocean hour after hour for weeks at a time. Are they demonstrating a sudden interest in our personal safety or are they hoping to collect enough data about the oil reserves along our protected coastline to help their friends in the fossil fuel industry? Their craving for oil is not as strong as our determination to protect our ocean.

Please help us protect our marine neighbors and our vulnerable fishing and hospitality industries. Despite PG&E's efforts to minimize concerns while attempting to steamroll this invasive testing program over the objections of extremely concerned local citizens, we're already seeing the effects of the "low-energy testing" they've been initiating over the last month. Surfers, fishermen, birdwatchers and others who spend a great deal of time on the ocean and along our shores have already reported disturbing sights: long-time fishermen report catching fish they've never seen before, another frequent sailor reported that he saw a whale he'd never seen before--and he has spent a great deal of time on this section of the Pacific Ocean. The animals already are experiencing distress from this "low energy" acoustic testing—distressed pelicans, dead dolphins, and large numbers of fish demonstrating bizarre behavior that reflects their distress from this preliminary testing. Imagine the terrible impact once PG&E starts testing at full levels: Sea Otters, California Gray Whales, Orcas, Rockfish and so many other sensitive, protected marine species will be destroyed—not harassed but destroyed—if this type of invasive acoustic testing is allowed to proceed.

Time is so short and PG&E is so intent to push concerned citizens out of the way for this unnecessary testing. It sure looks like they want to survey for oil at all costs and they don't care who will be destroyed along the way. Certainly, no one in the Central Coast wants this nuclear power plant on a fault line to giggle into a Fukushima, but this invasive testing—which is all about oil while ignoring the human and non-human costs—is not the answer. There are other ways to collect the data that must be recorded to

understand the seismic risks to this facility. This testing should focus on safety for those of us on shore and those swimming through the ocean not on generating a sneak peek of oil reserve data in the midst of severe carnage from this terrible acoustic seismic testing program.

Please help us to stop this destructive, short-sighted plan so we can save our beautiful, protected Central Coast and Marine Protected Areas. Fishermen haven't been able to drop a hook in these MPAs for years as the populations have recovered. Why squander this improvement to the ocean's health just because a wealthy corporation wants to make more and ever more money? This is a bad trade.

Thank you for reading our letters and taking our concerns to heart. We love the ocean as much as you all do and are determined to see these protected areas and sensitive communities preserved and protected. If you wish to hear more stories of how this "low-energy testing" is already impacting vulnerable animal populations, please feel free to contact me at 805/234-6331 or rad@ccfoodie.com. Please help us.

Sincerely,

Rachel Duchak, Principal
CentralCoastFoodie.com

10-16-12
PM

October 5, 2012

Dear Commissioners:

I'm writing to express my opposition to PG&E's Proposal for Seismic Testing on the Central Coast.

This project could have dangerous impacts on ocean ecosystems and recreational ocean users.

PG&E's own EIR clearly states unavoidable impacts to marine life. As an ocean enthusiast, I'm deeply concerned about the impacts to marine life during the testing. California is known for its rich ocean waters and we need to protect every level of our ocean ecosystem from risky and arguably unnecessary projects, such as seismic testing.

I'm also concerned that PG&E is disregarding the health and safety of ocean users. Their EIR clearly says the proposed activities would expose persons present in the water to harmful noise levels. And a recent PG&E map shows that dB levels could reach upward of 160 at some beaches. This is well over the threshold for human safety.

Finally, I'm concerned that PG&E is not analyzing decades of data collected by several sources to paint a full picture of geologic hazards near the power plant, new testing will only provide marginal improvement to what is already known.

Please deny this project. The Coastal Act was created to protect ocean resources and recreation. We believe this project does not conform to following sections of the Coastal Act:

**Section 30220--Protection of certain water-oriented activities-- Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas shall be protected for such uses.

**Section 30224--Recreational boating use--Increased recreational boating use of coastal waters shall be encouraged...

**Section 30230-- Marine resources; maintenance
Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.

**Section 30210-- Access; recreational opportunities; posting
In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs...
We urge you to deny this project and send PG&E "back to the drawing board" in order to protect marine life and ocean users from this unnecessary project.

Thank you in advance for your thoughtful consideration.

Sincerely,

Rachelle LaPan

ITP Goldstein <itp.goldstein@noaa.gov>

Comments on proposed IHA, 77 Fed. Reg. 58255

Rebecca Noblin <rnoblin@biologicaldiversity.org> Mon, Oct 15, 2012 at 6:26 PM
To: ITP.Goldstein@noaa.gov

Please see the attached comments from Center for Biological Diversity and Friends of the Earth regarding "Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California, November to December, 2012," 77 Fed. Reg. 58255 (Sept. 19, 2012). An electronic copy of sources cited in these comments is being mailed to:

Michael Payne, Chief

Permits and Conservation Division

Office of Protected Resources

National Marine Fisheries Service

1315 East-West Highway

Silver Spring, MD 20910-3225

Please let me know if you have problems opening this document or if you have questions.

Sincerely,

Rebecca Noblin

Alaska Director

Center for Biological Diversity

PO Box 100599

Anchorage, AK 99510-0599

Ph: 907-274-1110

Fax: 907-258-6177

www.biologicaldiversity.org

CBD & FOE Diablo Canyon IHA comments 10-15-12.pdf
50K

VIA EMAIL

Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910-3225
ITP.Goldstein@noaa.gov

October 15, 2012

Re: Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California, November to December, 2012, 77 Fed. Reg. 58255 (Sept. 19, 2012)

Thank you for the opportunity to comment on the National Marine Fisheries Service's (NMFS) proposed incidental harassment authorization (IHA) for the Lamont-Doherty Earth Observatory of Columbia University (L-DEO) and Pacific Gas and Electric Company (PG&E) to take marine mammals incidental to conducting a marine geophysical survey off the central coast of California in November and December 2012. These comments are submitted on behalf of the Center for Biological Diversity and Friends of the Earth. As discussed below, the proposed seismic survey will impact more than small numbers of marine mammals and will have a greater than negligible impact on species and stocks and therefore cannot legally be authorized under the Marine Mammal Protection Act (MMPA).

NMFS's IHA does not rely on the best available science regarding marine mammal impacts thresholds, including the 160-dB harassment threshold and the 180/190-dB Level A take exclusion zone threshold. Further, even if NMFS's assumptions regarding impact thresholds were correct, the IHA authorizes the take of more than small numbers of marine mammals and greater than negligible impacts on species and stocks, rendering the IHA as proposed illegal under the MMPA, especially with regard to the Morro Bay stock of harbor porpoises. NMFS also fails to take into account the best available science indicating that highly endangered western North Pacific gray whales may be taken by the proposed survey. For both this gray whale population and the highly endangered North Pacific right whale population, take of even one individual would constitute more than a negligible impact and would therefore violate the MMPA. Likewise, due to the high level of take of endangered sperm whales by fishing activities, NMFS cannot authorize additional take by the proposed survey and must address potential take to this deep-diving whale that feeds in the ocean's "sound channel." Finally, the National Environmental Policy Act (NEPA) requires NMFS to prepare a full environmental impact statement (EIS) analyzing the impacts of the proposed survey.

160-dB Level B Harassment Threshold

The proposed IHA uses the single sound pressure level of 160 dB re 1 µPa (RMS) as a threshold for behavioral, sublethal take in all marine mammal species affected by the proposed survey.[1] This approach does not reflect the best available science, and the choice of threshold is not sufficiently conservative in several important respects. In fact, five of the world's leading biologists and bioacousticians working in this field recently characterized the 160-dB threshold as "overly simplified, scientifically outdated, and artificially rigid."[2] The best available science indicates that NMFS must use a more conservative threshold.

Using a single sound pressure level of 160-dB for harassment represents a major step backward from recent programmatic authorizations. For Navy sonar activity, NMFS has incorporated into its analysis linear risk functions that endeavor to take account of risk and individual variability and to reflect the potential for take at relatively low levels.[3]

Furthermore, current scientific literature establishes that behavioral disruption can occur at substantially lower received levels for some species, including many species that will be impacted by the proposed survey here. For example, a single seismic survey has been shown to cause endangered fin and humpback whales to stop vocalizing – a behavior essential to breeding and foraging – and other baleen whales to abandon habitat over an area at least 100,000 square nautical miles.[4] Similarly, a low-frequency, high-amplitude fish mapping device was recently found to silence humpback whales at a distance of 200 kilometers, where received levels ranged from 88 dB to 110 dB.[5] Bowhead whales migrating through the Beaufort Sea have shown almost complete avoidance of seismic airgun received levels at 120 dB to 130 dB and below.[6]

Some odontocetes, such as beluga whales, are highly sensitive to a range of low-frequency and low-frequency-dominant anthropogenic sounds, including seismic airgun noise, which has been shown to displace belugas from near-coastal foraging areas out beyond the 130-dB isopleth.[7] Most worrisome for the proposed survey is the literature showing that harbor porpoises are acutely sensitive to a range of anthropogenic sounds, including airguns. They have

---

[1] 77 Fed. Reg. at 58260.
[2] Clark, C., Mann, D., Miller, P., Nowacek, D., and Southall, B., Comments on Arctic Ocean Draft Environmental Impact Statement at 2 (Feb. 28, 2012); *see* 40 C.F.R. § 1502.22.
[3] *See, e.g.*, 74 Fed. Reg. 4844, 4844-4885 (Jan. 27, 2009).
[4] Clark, C.W., and Gagnon, G.C., Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales (2006) (IWC Sci. Comm. Doc. IWC/SC/58/E9); *see also* MacLeod, K., Simmonds, M.P., and Murray, E., Abundance of fin (*Balaenoptera physalus*) and sei whales (*B. Borealis*) amid oil exploration and development off northwest Scotland, *Journal of Cetacean Research and Management* 8: 247-254 (2006).
[5] Risch, D., Corkeron, P.J., Ellison, W.T., and van Parijs, S.M., Changes in humpback whale song occurrence in response to an acoustic source 200 km away, PLoS ONE 7(1): e29741. doi:10.1371/journal.pone.0029741 (2012).
[6] Miller, G.W., Elliot, R.E., Koski, W.R., Moulton, V.D., and Richardson W.J., Whales, *in* Richardson, W.J. (ed.), Marine Mammal and Acoustical Monitoring of Western Geophysical's Open-Water Seismic Program in the Alaskan Beaufort Sea, 1998 (1999); Richardson, W.J., Miller, G.W., and Greene Jr., C.R., Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea, *Journal of the Acoustical Society of America* 106:2281 (1999).
[7] Miller, G.W., Moulton, V.D., Davis, R.A., Holst, M., Millman, P., MacGillivray, A., and Hannay. D., Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002, *in* Armsworthy, S.L., et al. (eds.), Offshore oil and gas environmental effects monitoring/Approaches and technologies, at 511-542 (2005).

been observed to engage in avoidance responses 50 miles from a seismic airgun array, a result that is consistent with both captive and wild animal studies showing them abandoning habitat in response to pulsed sounds at very low received levels, well below 120 dB.[8]

Although in the proposed rule NMFS cites many of these studies showing that low-frequency sounds in general and seismic surveys in particular can have significant behavioral impacts to marine mammals well below 160 dB,[9] NMFS irrationally sets the level B harassment threshold at 160 dB. If NMFS were to modify its threshold estimates, as it must based on the best available science, the estimated number of marine mammal takes incidental to the proposed seismic survey would be significantly higher than NMFS's current estimates.

180/190-dB Level A Take Threshold and Exclusion Zone

NMFS's use of the 180/190-dB threshold for Level A takes ignores the best available science and is non-conservative. As NMFS itself notes, a recent study by Lucke et al. on the temporary threshold shift (TTS) thresholds for harbor porpoises using seismic sounds demonstrates that a harbor porpoise experienced TTS when exposed to airgun noise at 164 dB. [10] It is therefore clearly irrational for NMFS to use a 180-dB threshold for Level A take for harbor porpoises specifically. Moreover, NMFS cannot rationally assume that other marine mammals will not incur injury at noise levels below 180/190 dB. The Lucke et al. study demonstrates that TTS can occur at different levels for different species of cetaceans. Thus, NMFS cannot assume that TTS and even permanent threshold shifts (PTS) would be unlikely for marine mammals that enter the exclusion zone.

In fact, there have been no studies on TTS thresholds in baleen whales, and little is known about PTS thresholds. However, a number of recent studies indicate that anthropogenic sound can induce PTS at lower levels than anticipated.[11] New data indicate that mid-frequency cetaceans have greater sensitivity to sounds within their best hearing range than was previously thought.[12] This recent research indicates it is possible marine mammals will experience injury, or potentially serious injury, at lower sound thresholds than NMFS assumes. NMFS must take into account the best available science and set lower thresholds for level A take, which would lead to larger exclusion zones around the survey.

---

[8] *See, e.g.*, Bain, D.E., and Williams, R., Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance (2006) (IWC Sci. Comm. Doc. IWC/SC/58/E35).

[9] 77 Fed. Reg. at 58265-68.

[10] Lucke, Klaus, Siebert, U., Lepper, P. a, & Blanchet, M.-A. (2009). Temporary shift in masked hearing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli. *The Journal of the Acoustical Society of America*, 125(6): 4060-70.

[11] Kastak, D., Mulsow, J., Ghoul, A., Reichmuth, C., Noise-induced permanent threshold shift in a harbor seal [abstract], *Journal of the Acoustical Society of America* 123: 2986 (2008); Kujawa, S.G., and Liberman, M.C., Adding insult to injury: cochlear nerve degeneration after "temporary" noise-induced hearing loss, *Journal of Neuroscience* 29:14077-14085 (2009).

[12] See discussion in Wood, J., Southall, B.L. and Tollit, D.J. (2012) PG&E offshore 3-D Seismic Survey Project EIR – Marine Mammal Technical Draft Report. SMRU Ltd.; Marine Mammal Commission, Marine Mammals and Noise: A Sound Approach to Research Management, Report to Congress, at 46 (March 2007).

Given NMFS's decidedly non-conservative approach to estimating impacts thresholds for injury to marine mammals from the proposed survey, it is likely that many more marine mammals will be harmed than NMFS estimates. In light of the best available science, NMFS cannot rationally defend its conclusion that the proposed survey will harm no more than small numbers of marine mammals and will have no more than negligible impacts on those species or stocks.

Marine Mammal Protection Act (MMPA): Small Numbers

Even if NMFS's assumptions regarding impacts thresholds were supportable, NMFS's own take estimates do not meet the requirements of the MMPA. Congress enacted the MMPA in 1972 in response to widespread concern that "certain species and population stocks of marine mammals are, or may be, in danger of extinction or depletion as a result of man's activities."[13] The legislative history states that the purpose of the MMPA is to manage marine mammals "for their benefit and not for the benefit of commercial exploitation."[14] The primary mechanism by which the MMPA protects marine mammals is through a moratorium on takings.[15] Under the MMPA, the term "take" is broadly defined to mean "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal."[16] "Harassment" is further defined to include acts of "torment" or "annoyance" that have the "potential" to injure a marine mammal or marine mammal stock in the wild or have the potential to "disturb" them "by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering."[17]

The MMPA provides several narrow exceptions to the moratorium on take. Relevant here, NMFS may, upon request, authorize take in the form of harassment by an IHA for a period of not more than one year, provided certain conditions are met. An activity: (i) must be "specified" and limited to a "specific geographical region," (ii) must result in the incidental take of only "small numbers of marine mammals of a species or population stock," (iii) can have no more than a "negligible impact" on species and stocks, and (iv) cannot have "an unmitigatable adverse impact on the availability of such species or stock for taking for subsistence uses" by Alaska Natives.[18] In issuing an authorization, NMFS must provide for the monitoring and reporting of such takings and must prescribe methods and means of affecting the "least practicable impact" on the species or stock and its habitat.[19] Finally, for an IHA to issue, the activity cannot have the "*potential* to result in serious injury or mortality."[20]

Here NMFS has blatantly disregarded the MMPA's prohibition on allowing the take of more than small numbers of marine mammals.[21] Most egregiously, NMFS estimates that

---

[13] 16 U.S.C. § 1361(1).
[14] H. Rep. No. 92-707, at 11 (1971), reprinted in 1972 U.S.C.C.A.N., pp. 4144, 4154.
[15] 16 U.S.C. § 1371(a).
[16] *Id*. §1362(13).
[17] *Id*. § 1362(18); *see also* 50 C.F.R. § 216.3 (defining "Level A" and "Level B" harassment).
[18] *See* 16 U.S.C. § 1371(a)(5)(D)(i).
[19] *Id*. § 1371(a)(5)(D)(ii)(I).
[20] 50 C.F.R. § 216.107 (emphasis added).
[21] 16 U.S.C. § 1371(a)(5)(D)(i).

between 1,119 and 1,513 harbor porpoises from the Morro Bay stock will be taken, which is approximately 59 percent to 74 percent of the population.[22] As noted above, given harbor porpoises' sensitivity to noise, this extremely high number is likely an underestimate. But even taking it at face value, NMFS cannot rationally argue that this is a small number. There is no numerical cut-off for "small numbers."[23] However, courts have concluded that "[a] definition of 'small number' that permits the potential taking of as much as 12% of the population of a species is plainly against Congress' intent."[24]

NMFS does not even attempt to explain how its take estimates meet the "small numbers" requirement. In fact, the IHA here entirely disregards this statutory requirement. Although the statutory language is mentioned, NMFS does not attempt to define small numbers, nor does it undertake any sort of analysis of what small numbers might be. The Ninth Circuit recently confirmed that the MMPA requires the authorizing agencies (in this case NMFS) to separately find both that only small numbers of marine mammals will be harmed and that the impacts to the species or stock will be negligible.[25] While NMFS attempted to rationalize its determination that impacts to the species or stocks will be negligible, it undertook no such analysis regarding small numbers.

In failing to separately analyze the small numbers standard and the negligible impact standard, NMFS defied clear congressional intent. As the Ninth Circuit stated in *CBD v. Salazar*, "[l]egislative history confirms our reading of the statute if such confirmation is needed. The House Report accompanying Section 101(a)(4)-(5) of the MMPA indicates that Congress intended "small numbers" and "negligible impact" to serve as two separate standards."[26] The requirement that NMFS authorize the take of only "small numbers" of individual animals is no mere technicality. Congress's intent was that the MMPA protect not only populations, but individual marine mammals.[27] While the "negligible impact" standard should serve to protect the species or population as a whole, the "small numbers" requirement guarantees that Congress's directive to protect individual marine mammals is carried out. The IHA here violates the MMPA because it does not guarantee that only small numbers of marine mammals will be taken.

Although NMFS attempts to minimize the take of the Morro Bay stock of harbor porpoises through a monitoring plan,[28] NMFS recognizes the potential for the take of large numbers of harbor porpoises.[29] The MMPA definition of harassment is focused on "potential harassment," which supports the conclusion that all of the animals in a population are harassed "if there is the *potential* for the act to disrupt the behavioral patterns of the most sensitive

---

[22] 77 Fed. Reg. 58286.
[23] *See* H.R. Rep. No. 97-228 (1981), reprinted in 1981 U.S.C.C.A.N. 1458, 1469 ("[small numbers] is not capable of being expressed in absolute numerical limits.").
[24] *Natural Res. Def. Council v. Evans*, 279 F. Supp. 2d at 1129, 1152 (N.D. Cal. 2003).
[25] *Center for Biological Diversity v. Salazar*, -- F.3d --, Case No. 10-35123, 2012 WL 3570667 at *6 (9th Cir. Aug. 21, 2012).
[26] *Id.*
[27] *See* 16 U.S.C. § 1362 (18)(A) (definition of "harassment" expressly applies to acts that affect "a marine mammal or marine mammal stock in the wild."); *see also Natural Res. Def. Council v. Evans*, 364 F. Supp. 2d at 1083 1109 (N.D. Cal. 2003) ("In expressing concern about harassment to 'a marine mammal,' Congress was concerned about harassment to individual animals.").
[28] 77 Fed. Reg. at 58287.
[29] 77 Fed. Reg. at 58286.

individual in the group."[30] The MMPA only allows NMFS to authorize "the incidental, but not intentional, taking by harassment of *small numbers* of marine mammals."[31] Thus, even if all the estimated takes do not actually occur, the *potential* for those large takes to occur still exists, and should be included in the analysis of small numbers according to the definition of "harassment."

NMFS's failure to meet the small numbers and negligible impacts requirements is all the more irrational because NMFS is only considering impacts from half of the proposed survey. NMFS explains that the seismic survey will be conducted over two years, but it only analyzes impacts from the first half of the two-part survey. If it were looking at the whole survey, as the MMPA requires, NMFS would be forced to conclude that even higher numbers of marine mammals would be taken, and the likelihood of more than negligible impacts would be even greater. NMFS cannot break down its analysis of the survey in order to artificially underestimate harm.

Potential to Take Highly Endangered Western North Pacific Gray Whales, North Pacific Right Whales and Sperm Whales

In its estimates of gray whale take, NMFS does not even consider the possibility that it may take individuals from the highly endangered western North Pacific gray whale population. The best available science indicates western North Pacific gray whales may be present in the survey area. Recently, a tagged western North Pacific gray whale traveled all the way from Sakhalin Island, Russia, to the west coast of North America,[32] indicating that the population may merge with the eastern North Pacific population during migration and may therefore be taken by the proposed seismic survey. There are currently an estimated 130 western North Pacific gray whales left in the world.[33] With such low population numbers, the take of even one of these whales would have greater than negligible impacts on the species or stock.

The North Pacific right whale is another possibly impacted species for which no take may be authorized under the MMPA. There are an estimated 25 to 30 individuals in the eastern stock of North Pacific right whales, making it the most highly endangered large whale in the world.[34] Although NMFS notes that North Pacific right whales may be present in the project area, it assumes, without support, that no North Pacific right whales will be taken. NMFS cannot rationalize the authorization of a seismic survey that has the potential to take a single North Pacific right whale.

Lastly, NMFS does not consider the potential for sperm whale take, saying only that while in the range of seismic surveys, "sperm whale sightings are uncommon in the proposed

---

[30] *Natural Res. Def. Council v. Evans*, 279 F. Supp. 2d 1129, 1157 (N.D. Cal. 2003) (emphasis added; in dicta); *see also* 16 U.S.C. § 1362(18)(A)(ii) (defining harassment to include any act of pursuit, torment, or annoyance that "has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns").
[31] 16 U.S.C. § 1362(5)(D).
[32] *See* http://mmi.oregonstate.edu/Sakhalin2010.
[33] Report of the Scientific Committee, Tromsø, Norway, 30 May to 11 June 2011 Annex F: Sub-Committee on Bowhead, Right and Gray Whale". *IWC Office*.
[34] Wade, P., A. Kennedy, R. LeDuc, *et al*. 2011*b*. The world's smallest whale population? Biology Letters 7:83–85.

project area, and have a low likelihood of occurrence during the proposed seismic survey."[35] This is in spite of the fact that sperm whales reach peak abundance in California from April through mid-June and from the end of August through mid-November,[36] which is during the time of the proposed survey. Any take of a sperm whale would have greater than negligible impacts on the stock because NMFS must take into account the cumulative take of sperm whales from other activities, including incidental catch by fisheries. The California drift gillnet fishery, which operates primarily in southern California from August through January, took an estimated sixteen endangered sperm whales in the 2010-2011 fishing season.[37] Including both fishery and ship-strike mortality, the average annual rate of kill and serious injury is four endangered sperm whales, exceeding the potential biological removal level of 1.5.[38] With an estimated 971 sperm whales in the population, this level of anthropogenic take cannot be considered a negligible impact.

National Environmental Policy Act (NEPA)

NEPA requires federal agencies to prepare an EIS for all "major Federal actions significantly affecting the quality of the human environment."[39] The scope of this requirement is "exceptionally broad,"[40] and it is intended to "compel agencies . . . to take seriously the potential environmental consequences of a proposed action."[41]

NMFS notes that the National Science Foundation has prepared a draft environmental assessment to determine whether its marine seismic surveys may have a significant effect on the human environment.[42] We believe, based on multiple factors in NEPA's regulations, that the proposed activities do constitute a significant impact and encourage NMFS to prepare a full EIS.[43]

---

[35] 77 Fed. Reg. 58262.
[36] Caretta et al. 2012 (Draft) U.S. Pacific Marine Mammal Stock Assessments at 22 (citing Rice, D.W. 1974. Whales and whale research in the eastern North Pacific. pp. 170-195 In: W.E. Schevill (ed.). The Whale Problem: A Status Report. Harvard Press, Cambridge, MA.) available at http://www.nmfs.noaa.gov/pr/sars/.
[37] Caretta, J.V. and L. Enriquez. 2012. Marine Mammal and seabird bycatch in California gillnet fisheries in 2010. Administrative report LJ-12-01, available at http://swfsc.noaa.gov/uploadedFiles/Divisions/PRD/Programs/Coastal_Marine_Mammal/2010_Bycatch_Estimates_Carretta_Enriquez%20LJ-12-01.pdf.
[38] Caretta et al. 2012 (Draft) U.S. Pacific Marine Mammal Stock Assessments at 23-25.
[39] 42 U.S.C. § 4332(C).
[40] *Found. for N. Am. Wild Sheep v. United States Dep't of Agric.*, 681 F.2d 1172, 1177 (9th Cir. 1982).
[41] *Ocean Advocates v. United States Army Corps of Eng'rs*, 402 F.3d 846, 864 (9th Cir. 2005).
[42] 77 Fed. Reg. 58256.
[43] *See* 42 U.S.C. § 4332(2)(c); 40 C.F.R. § 1508.27; *Idaho Sporting Cong v. Thomas*, 137 F.3d 1146, 1149 (9th Cir. 1998) ("[A]n EIS must be prepared if 'substantial questions are raised as to whether a project . . . may cause significant degradation of some human environmental factor").

Conclusion

For all of the foregoing reasons, the IHA as proposed violates the MMPA and should not be granted. Electronic copies of the scientific sources cited in this letter are being sent by mail. Please do not hesitate to contact us if you have questions.

Sincerely,

Rebecca Noblin
Alaska Director
Center for Biological Diversity
PO Box 100599
Anchorage, AK 99510-0599
Ph: 907-274-1110
Fax: 907-258-6177
www.biologicaldiversity.org

Damon Moglan
Climate and Energy Director
Friends of the Earth
1100 15th St NW, 11th Floor
Washington, D.C. 20005
Phone: (202) 222-0708
Fax: (202) 783-0444
www.foe.org

This message has been automatically translated: Portuguese -> English.

ITP Goldstein
<itp.goldstein@noaa.gov>

Absurdity Protest Portuguese BR

Renato Gonçalves Viveiros Lima <rgvl@ig.com.br> **Tue, Oct 16, 2012 at 9:17 AM**
To: ITP.Goldstein@noaa.gov

16/10/12
And so absurd killing what purpose beyond sangria?
Need it even?
And Fututas generations, such as enjoyed!
Or just for the money and?

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Diablo Canyon Seismic Testing

Howard Goldstein <howard.goldstein@noaa.gov> Tue, Oct 16, 2012 at 10:47 PM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Renee** <renee@rightstepmarketing.com>
Date: Tue, Oct 16, 2012 at 10:43 PM
Subject: Diablo Canyon Seismic Testing
To: Howard.Goldstein@noaa.gov

Dear Mr. Goldstein:

I respectfully urge you to consider and use your influence to vote down the Seismic Testing scheduled for Diablo Canyon.

This is a terrible assault to the marine life environment that should not be tolerated.

Can you imagine if they were using the equivalent of the same testing in your neighborhood????? 260db sound blasts in their environment every 13 seconds, 24/7 for 30+ days????

Can you imagine what an effect it may have to your health by the end of such a testing period??? That is, if you "chose not to" or "could not" flee your neighborhood at the earliest opportunity.

Wildlife is a precious asset that the human family has been entrusted to protect against the selfish interest that would disrespect their right to share our planet.

They deserve better consideration. These number of "take" in the EIR are unacceptable. Level "A" Harrassment we know will lead to Level "B" injury and death in many cases.

This information being sought comes at too high a price. There has to be another way of collecting the data being sought while respecting and preserving resident wildlife.

Secondly, I would really like to be able to make sense of the "true value" of the test results and how that information can be used to make Diablo Canyon Nuclear Power Plant, a "safer" operation as it continues to operate on top of and adjacent to earthquake faults.

The information gleaned from mapping cannot help us AVOID a quake. As we have seen in numerous natural disasters, mankind continues to underestimate Mother Nature. So, please explain how having a map is going to change any forseeable outcome to a major quake and a nuclear power plant????

Respectfully,

Renee Metoyer
PO Box 10725
Glendale, AZ 85318

[Quoted text hidden]

ITP Goldstein <itp.goldstein@noaa.gov>

NOAA Comment letter, Proposed PG&E seismic testing Estero Bay, Ca.

Richard E.T. Sadowski <r.e.t.sadowski@gmail.com> Mon, Oct 15, 2012 at 2:03 PM
To: ITP.Goldstein@noaa.gov
Cc: Marla Jo Bruton <woollymamma@yahoo.com>

October 15, 2012

To: P. Michael Payne, Chief Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway, Silver Spring, MD 20910

From: Richard E.T.Sadowski and Marla jo Bruton
Citizens Opposing Acoustic Seismic Testing (C.O.A.S.T. alliance), Morro Bay, Ca. members

We are opposed to the acoustic seismic testing that is proposed by PG&E with regards to the Diablo Canyon Nuclear Power Plant (DCPP).
Besides the obvious violations to the MLPA, Endangered Species Act, Magnuson-Stevens Sustainable Fisheries Act and California's Coastal Act just to name a few:

Why isn't NOAA in collaboration with the Bureau of Safety and Environmental Enforcement (BSEE) under the Bureau of Ocean Energy Management (BOEM) analyzing the current data from 'Low Energy' seismic testing that has been going on for the last 2 years and weighing in on the proposed High Energy Seismic Survey (HESS) that is scheduled to start next month in November 2012 ?
(It is my understanding that this data has not been thoroughly vetted by appropriate federal and state agencies.)

With the BOEM currently looking into the Peruvian mass mortality of dolphins from seismic testing using air cannons, would it not make common sense for the federal agencies like NOAA, U.S. Fish and Wildlife, and National Institute of Standards and Technology (NIST) to collaborate proactively with other federal and state agencies in a non-destructive study regarding the effects of HESS ?

Given that NOAA's National Marine Fisheries Service (NMFS) is responsible for management of California's Exclusive Economic Zone (EEZ) as defined by UNCLOS Law of the Sea,

What is NOAA's position on how the proposed PG&E acoustic seismic test will affect the United Nations Agreement relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks ?

Under this agreement it is stated that:

"The Agreement, considered a highly innovative treaty, establishes a modern, comprehensive and detailed legal regime to ensure the long-term conservation and sustainable use of straddling fish stocks and highly migratory fish stocks by: ...

Requiring the application of the precautionary approach to fisheries conservation and management—calling on States to be more cautious when information is uncertain, unreliable or inadequate.
Under this approach the absence of adequate scientific information shall not be used as a reason for postponing or failing to take conservation and management measures."
(bold emphases added)

Thank you for taking the time and consideration to answer my questions regarding this critically important issue.

Respectfully,

Richard E.T.Sadowski
Mechanical Engineer

Marla jo Bruton
C.O.A.S.T. Alliance member

C.O.A.S.T. Alliance member
490 Java Street
Morro Bay, Ca. 93442

ITP Goldstein <itp.goldstein@noaa.gov>

Seismic testing @California coast: First do no harm.

Risa Mandell <rmm635@gmail.com> Sat, Oct 13, 2012 at 12:48 PM
To: ITP.Goldstein@noaa.gov

Hello:

I oppose the seismic testing above because it will have a detrimental effect on marine life including fish, invertebrates and marine mammals, will result in the stranding of large mammals as well as result in sever tachycardia for beluga whales. This proposal is rushed and the levels of impact are not investigated enough and not accessed based on the best scientific evidence available. The company's planned actions lack transparency, they should be required to fully and publicly disclose where activities take place, what equipment will be used, exact Sound Pressure Levels, when activities will take place. Additionally, marine mammal observers logs where they record all marine mammal sightings should be publicly available. NMFS should deny the permit based on omission of the best scientific evidence available and inadequate assessment of impact on marine life.

The human mindset of dominance towards all that lives needs some humility. Centuries pillage and plunder of the planet's ecology and all who inhabit it have resulted in severe, chronic damage impairing the health of numerous ecosystems. The human job now is to repair and all business that seeks its venture in the natural world ought to find sustainable ways to profit from their investments. It's time the Hippocratic oath, First do no harm be applied to business.

I look forward to your response.

Thank you,

Risa M. Mandell
rmm635@gmail.com

ITP Goldstein <itp.goldstein@noaa.gov>

What are we doing?

Roberta Velez Gama <robertavelezgama@gmail.com> Mon, Oct 15, 2012 at 1:48 PM
To: ITP.Goldstein@noaa.gov

How long are we going take lives to "save" lives!?

There is no justification for something like that, what about create research about diseases that kill our children instead hurting animals????? Stop harming those poor creatures from the ocean! They are beautiful and they don't cause any harm to us, Humans. If we can still call ourselves that, we are worst than animals, we are monsters and just think about money and power! It's time to rethink what we are doing to this planet. There is no more time for war, save your family and your planet while you can. Don't be Stupid!!!!

Did you ever see the smile on the face of the a little kids that see the dolphins and whales jumping and playing???? Don't take that from them! Let the new generation enjoy the beautiful and natural ritual that only those animals have! I chalenge you, COLD MEAN HUMAN, to take your children to a whale/ dolphin sighting and I want to see if you going to change your mind, if you don't, Kill yourself because you are a heartless piece of crap!

Roberta Velez
Rio de Janeiro, Brazil.

ITP Goldstein <itp.goldstein@noaa.gov>

Seismic test out the California coast

Roberto Gianelli <2500rob@gmail.com> Mon, Oct 15, 2012 at 5:55 AM
To: ITP.Goldstein@noaa.gov

Dear P. Michael Payne, Chief, Permits and Conservation Division, Office of Protected Resources, National Marine Fisheries Service, Please don't test armament out the Cali coast, lots of marine mammals out there and its known that they can be kill by armament tests and ultrasounds! Please preserve those beautiful creatures! In front of the California coast there's one of the biggest marine mammal sanctuary area!!
Please think bout them and our ocean! We depend on it to survive.

Thanks for reading

Mr. Roberto Gianelli from Italy

ITP Goldstein <itp.goldstein@noaa.gov>

PGE'S PENDING ASSAULT ON THE SEA

roger andriola <roger_andriola1@mail.com> Wed, Sep 26, 2012 at 11:01 AM
To: ITP.Goldstein@noaa.gov

NATIONAL MARINE FISHERIES SERVICE PERMITS CHIEF P. MICHAEL PAYNE:

Please consider these comments from concerned California central coast citizen. Thank you.

An open letter to the CALIFORNIA STATE COASTAL COMMISSION ON PG&E'S PENDING SEISMIC PERMIT HEARING

On Sunday afternoon, August 26th, 2012, quite by happenstance, I happened to see, out at sea, a sight of such awesome majesty, I can not find the words to describe it. As I watched, through a spotting scope, breathless, in jaw-dropping disbelief, one of the greatest spectacles in nature, was unfolding, being staged in the coastal waters off Cambria, an event that I will cherish seeing till the day I die.

The surface of the sea was surging and boiling, as about a dozen, huge, black and dark grey backed whales, blowing 'sail-like vertical sheets' of white misted spray, would slowly surface, roll forward, raise their flukes high into the air and plunge back down. All the while, a storm of stately brown pelicans fluttering overhead, were diving, wings swept back, long bills pointing downward, aiming, into the sea. It must have taken a good quarter hour, as I continued to try to adjust the focus and direction, nearly three quarters of the way out toward the horizon, before I could fully figure out what it was I was a watching, an immense whale and pelican partner, massive school of fish, feeding frenzy, and then another couple hours before this God-given, theatre-of-life performance, played out, and I was able to slowly disengage my face from the eye piece, and try to straighten up my back. With no one else seen watching, I would be the one to bear witness to this breathtaking event.

I hear that PG&E,
not known for its corporate integrity, well known for its past decade of deception, is now making the false claim that still, it can not comprehend that it built its Diablo Canyon nuclear power plant on a California coast riddled with present, and future, earth quake faults, nor recall that it did so deliberately, (I think it was in the early 1980's), over a storm of protest;
is making the further false claim that it can not figure out if earth quakes might pose a hazard, that it can not find out what that hazard might be without using underwater cannon-like explosions, up to 250 decibel air blasts, to destroy the eardrums and lives of the marine mammals and sea food life of the california scenic central coast, and beyond, that suddenly, after more than a quarter century of indolent indifference, it needs to do so immediately, and that, whatever it may later claim the results to be, it fully intends to continue doing what it has always done, deceive the public into believing that its nuclear power plant is a source of cheap, clean, safe, essential energy.

This pending, for profit, PG&E energy giant, corporate coup d'etat, assault on the sea, on its 'California scenic central coast sacrifice zone', this proposed 'seismic testing act of environmental violence', to explore for exploitable off-shore oil deposits, the same testing which murdered a thousand dolphins in Peru earlier this year, if not stopped, will eventually become an act of violence against all of us, an assault on our children, and on our children's children, for we, and PG&E, all are part of the same web of life.

The purpose of the State Lands Commission public hearing expose, the 'STATE LAND COMMISSION'S

PG&E PERMIT HEARING,' document attached hereto, is to point out that the central coast people who attended through the Morro Bay video conferencing, do not believe that State Lands was a legitimate government entity performing a lawful public hearing. They believe, for the very reason inadvisedly admitted by its acting Chair while he was interrupting public comment, that it, already, was a "done deal," making clear that what he was conducting was nothing more than a 'pretend for public show' hearing. This leaves us no choice but to conclude, that the 'permit' State Lands approved for PG&E'S seismic testing, has no legal validity.

The second attachment, 'PG&E'S PENDING ASSAULT ON THE SEA AND GRAY WHALES', is to put PG&E'S proposed oil exploration seismic testing into proper historical and whale evolutionary extinction context, without which it is not possible to properly evaluate it.

Why wait till we terrestrial mammals, the bewildered American herd, always kept fully uninformed, by the high journalistic standards of the mainstream media, begin to hear the seemingly unending sounds, the muffled booms coming from the sea, and wonder what it is that might be happening out there, the annoying booms becoming a permanent part of our busy lives, interfering with our land-based happy talk, as unseen, out at sea, out of sight, and through the night, the blood begins to rise, slowly, silently.

Because it does not now look like I can make it to your upcoming public meeting, please read the two attached 'public presentations', stop PG&E now, permanently, and save our precious marine mammal wild sea life.

Thank you kindly for carefully considering all public input, for watching out for the whales who can not attend, for trying to hear their wise comment, and for making the only, unquestionably 'ethically correct,' decision.

roger andriola, Cambria

cc: State Senator Sam Blakeslee, State Assemblyman Katcho Achadjian, U.S. Congresswoman Lois Capps, the California Coastal Commission, our Governor, the good, Edmund G. (Jerry) Brown Jr, and Greenpeace, the Planet's Protector of Whales.

ITP Goldstein <itp.goldstein@noaa.gov>

OPPOSE: Proposed Incidental Harassment Authorization; Request For Comments.

Russ Hobbs, PA-C <palt@charter.net>
To: ITP.Goldstein@noaa.gov

Mon, Oct 15, 2012 at 1:42 PM

October 15, 2012

P. Michael Payne, Chief, Permits and Conservation Division,

Office of Protected Resources, National Marine Fisheries Service,

1315 East-West Highway, Silver Spring, MD 20910.

Strongly Oppose: I urge you to Stop the proposed High-energy Seismic Survey of the California Coast

Dear Chief Payne:

My name is Russ Hobbs. I am a Physician Associate, and concerned citizen of California's Central Coast. I am not some Environmental Wacko nut job, and ask you to please deny the IHA permit.

PG&E is currently in the beginning phases of the process of conducting High-Energy Seismic testing off our coast for purposes of "mapping" the Hosgri, Los Osos and Shoreline fault zones in the region of Estero Bay, near the Diablo Canyon Nuclear Power Plant and the city of Morro Bay CA.

As a Physician Associate and former Commercial Abalone Diver, I am eminently qualified both as a scientist and diver, whose education and training in biological science coupled with my experience as a commercial diver, do indeed make me very well familiar with the marine life in our coastal waters Further, not only as a concerned citizen, but as a qualified professional, **I demand immediate action** to stop this dangerous *experimental* testing.

This urgent request is made to prevent *irreversible damage* to the marine environment this so-called "survey" will cause. Further, and certainly no less important, I am opposed to being handed my "share of cost" in the form of PG&E rate hikes to cover the costs to PG&E itself that this Survey will incur. I believe it to be in neighborhood of $16 Million, and was secured by PG&E in the form of funding for this survey.

There are 2 fundamental issues here:

1. I have been advised that this survey has been called for by the State of California under AB 1632 (2006 Blakeslee). Read it please – it requires a REVIEW of EXISTING DATA **not** NEW data.

   The State of CA has since (2008) decided to revisit DCNPP's Seismic safety. Since when does the CA State Energy Commission and the State PUC override Federal Policy and Procedure on Environmental issues?

2. In this turned-down economy, and at a time when the California State budget deficit is estimated to exceed 16 Billion dollars by Governor Brown, in a report dated May 13th, 2012, I ask who will pay for this "new" survey???

Background:

There were ample studies done back in the 1960s through the 1980s when the construction and implementation of Diablo Canyon Nuclear Power Plant (DCNPP) was first conceived and later commissioned. Now in extremely tenuous economic times "they" want to re-invent the wheel. For what purpose and to what end? To obtain updated information to retro-fit the DCNPP facility to withstand the worst case earthquake scenario? It is currently rated to withstand a 7.5 Magnitude seismic event. Anything more than that would essentially level most structures in the "impact zones". How is this study going to benefit the citizens who live in the area? By the time the results are published, plans are made and approved for a subsequent retrofit, the facility will be up in 2024 for new licensing by the NRC. Why is all this happening – because of paranoia and panic evoked by the Fukushima disaster in Japan? Come on – you guys are best and brightest Harvard, Yale, MIT, Cal Tech, Cal-Poly, Stanford and USC (my alma-mater). What are these people thinking--or more appropriately have you studied the data and considered why this has been allowed to go forward to this stage? It is clear from the data in the EIR and in the Federal Register that the survey will cause "takes" to protected and endangered species off our coast with unknown long term consequences to both the Marine Species and to the environment itself. You know as well as I that the numbers and percentages presented are very conservative and that the statistical data contained therein have been "manipulated" to mitigate the projected and actual impact to the affected species and environment itself.

The "low-energy" testing phases have already begun. Recently, I have seen two separate specimens of pinnipeds (a California sea lion and a Pacific harbor seal) with nasal hemorrhage (bloody noses) one in Morro Bay and the other in Port San Luis, (Avila Beach) which I initially attributed to "sparring" with one another. However in view of the time of year, and the recent ongoing "low energy" seismic testing, I am not so sure of my initial assessment of the etiology of those hemorrhages.

In closing, I make another appeal to you to please deny this IHA permit. Please re-read and consider all input prior to making your decision.

I am including the links to the documents that I have reviewed when I was made aware of the proposed studies :

National Register

https://www.federalregister.gov/articles/2012/09/19/2012-22999/takes-of-marine-mammals-incidental-to-specified-activities-marine-geophysical-survey-off-the-central#h-57

Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California, November to December, 2012

A Notice by the National Oceanic and Atmospheric Administration on 09/19/2012

CA Coastal Commission Reports (EIR) and Marine Fisheries

http://www.coastal.ca.gov/energy/seismic/seismic-survey.html

Thank you for taking the time to review my input and comments during this period of Open Comment.

Best Regards,

Russ Hobbs, PA-C

Board Certified Physician Associate

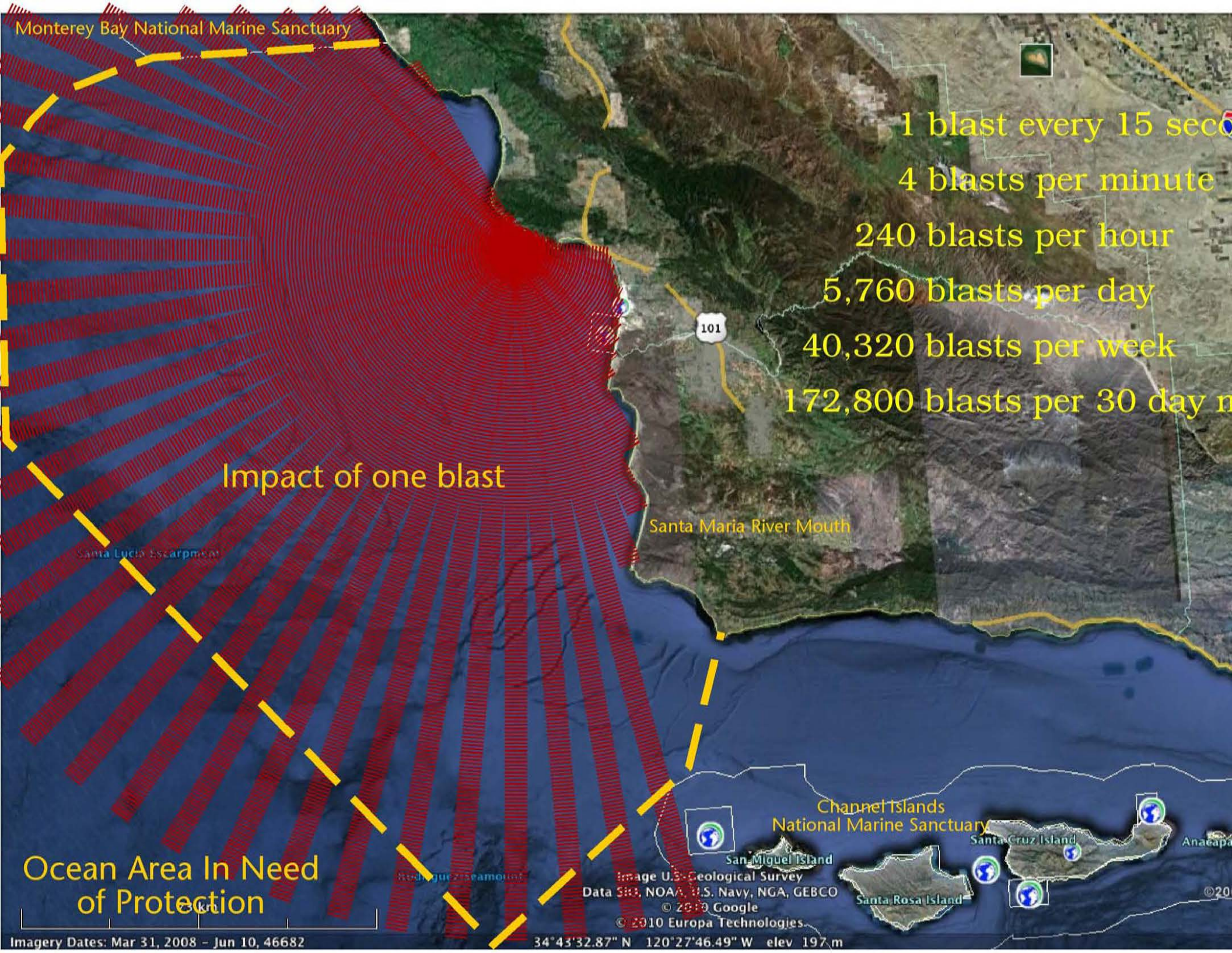
Primary Care Medicine

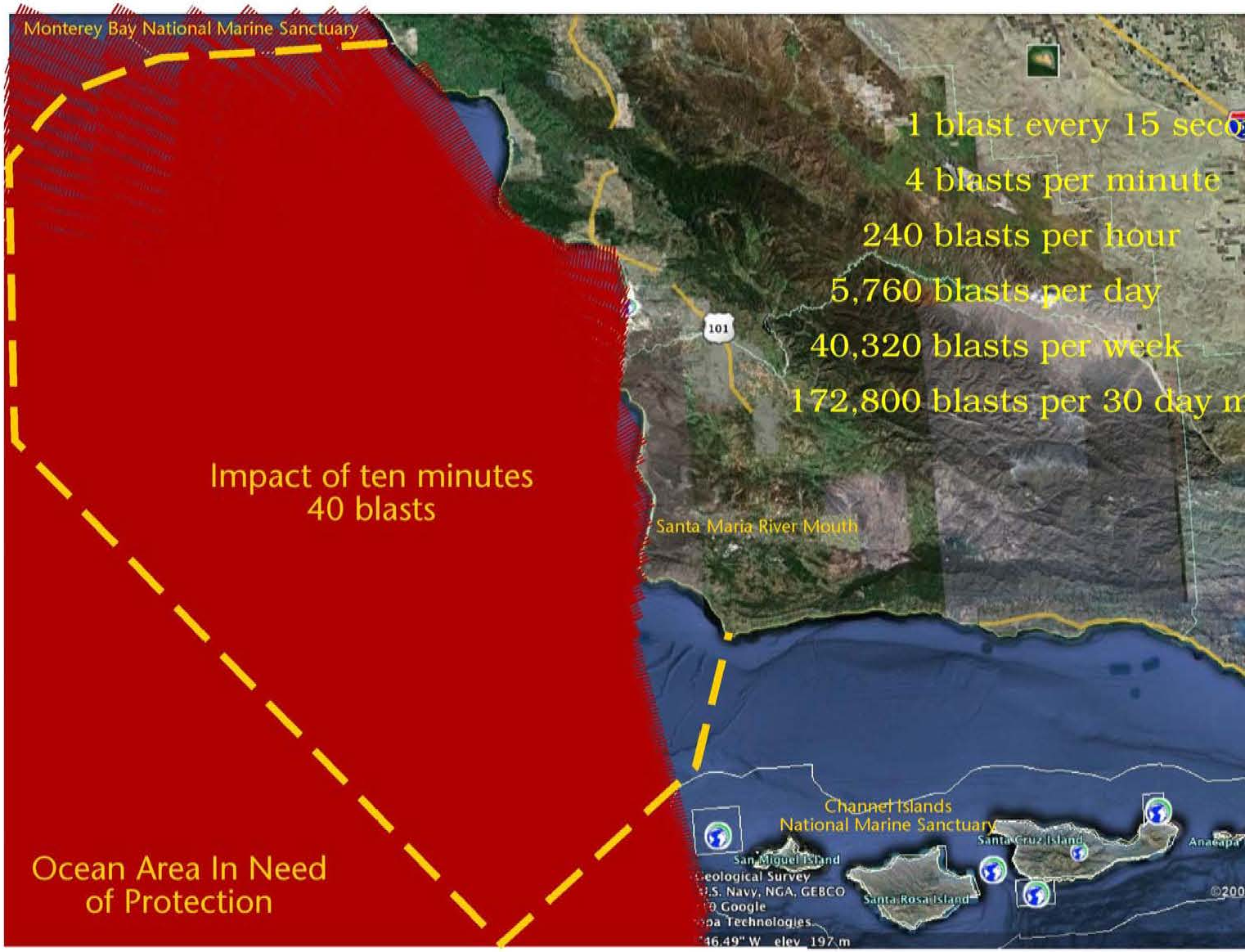
Contact Info:

PO Box 513

Arroyo Grande, CA 93421-0513

e-mail: palt@charter.net (professional)


Monterey Bay National Marine Sanctuary
1 blast every 15 seco
4 blasts per minute
240 blasts per hour
5,760 blasts per day
40,320 blasts per week
172,800 blasts per 30 day m
101
Impact of one blast
Santa Maria River Mouth
Santa Lucia Escarpment
Channel Islands
National Marine Sanctuary
Santa Cruz Island
San Miguel Island
Santa Rosa Island
Anacapa
Ocean Area In Need
of Protection
Image U.S. Geological Survey
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2010 Google
© 2010 Europa Technologies
Imagery Dates: Mar 31, 2008 – Jun 10, 46682
34°43'32.87" N 120°27'46.49" W elev 197 m


Monterey Bay National Marine Sanctuary
1 blast every 15 seco
4 blasts per minute
240 blasts per hour
5,760 blasts per day
40,320 blasts per week
172,800 blasts per 30 day m
101
Impact of ten minutes
40 blasts
Santa Maria River Mouth
Channel Islands
National Marine Sanctuary
Santa Cruz Island
Anacapa
San Miguel Island
Santa Rosa Island
Ocean Area In Need
of Protection

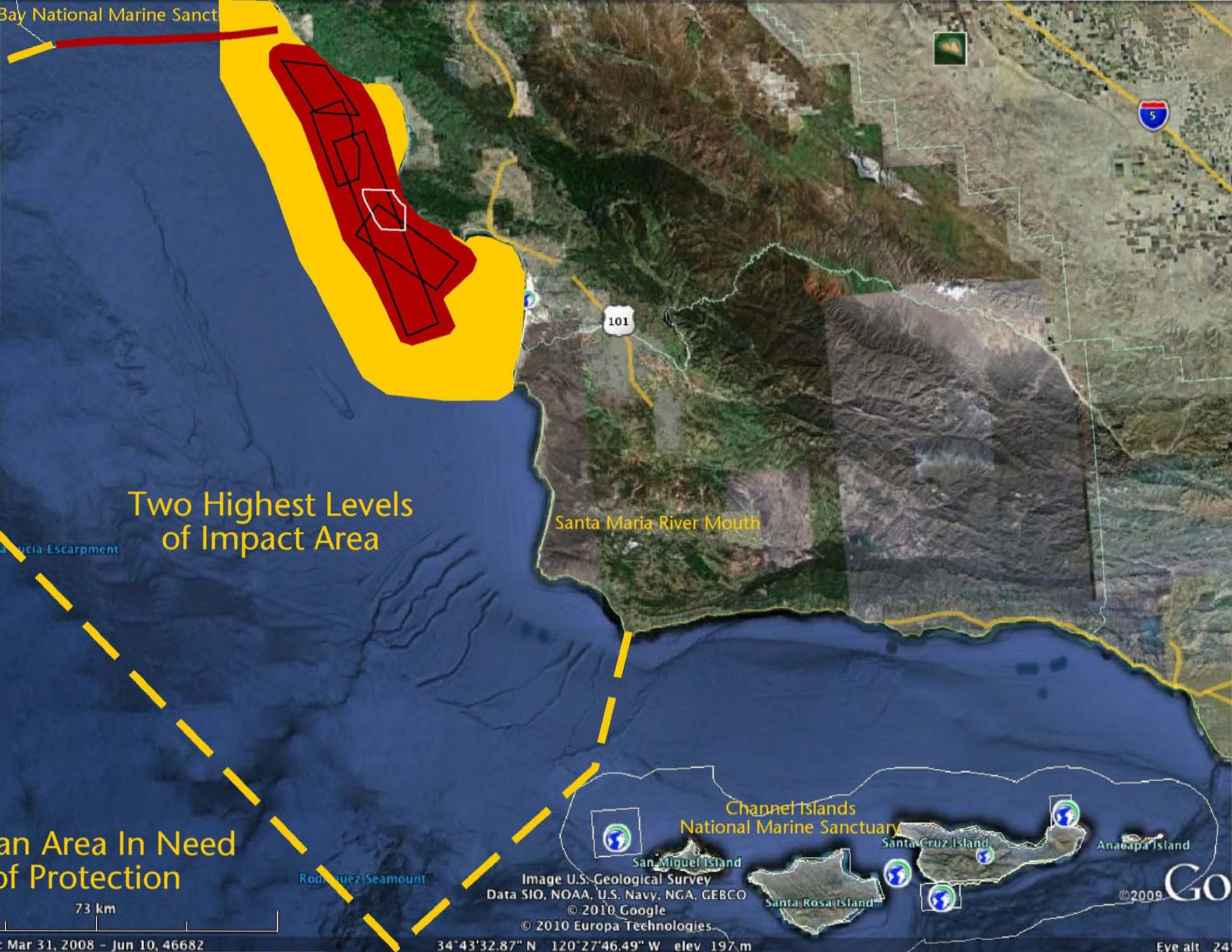
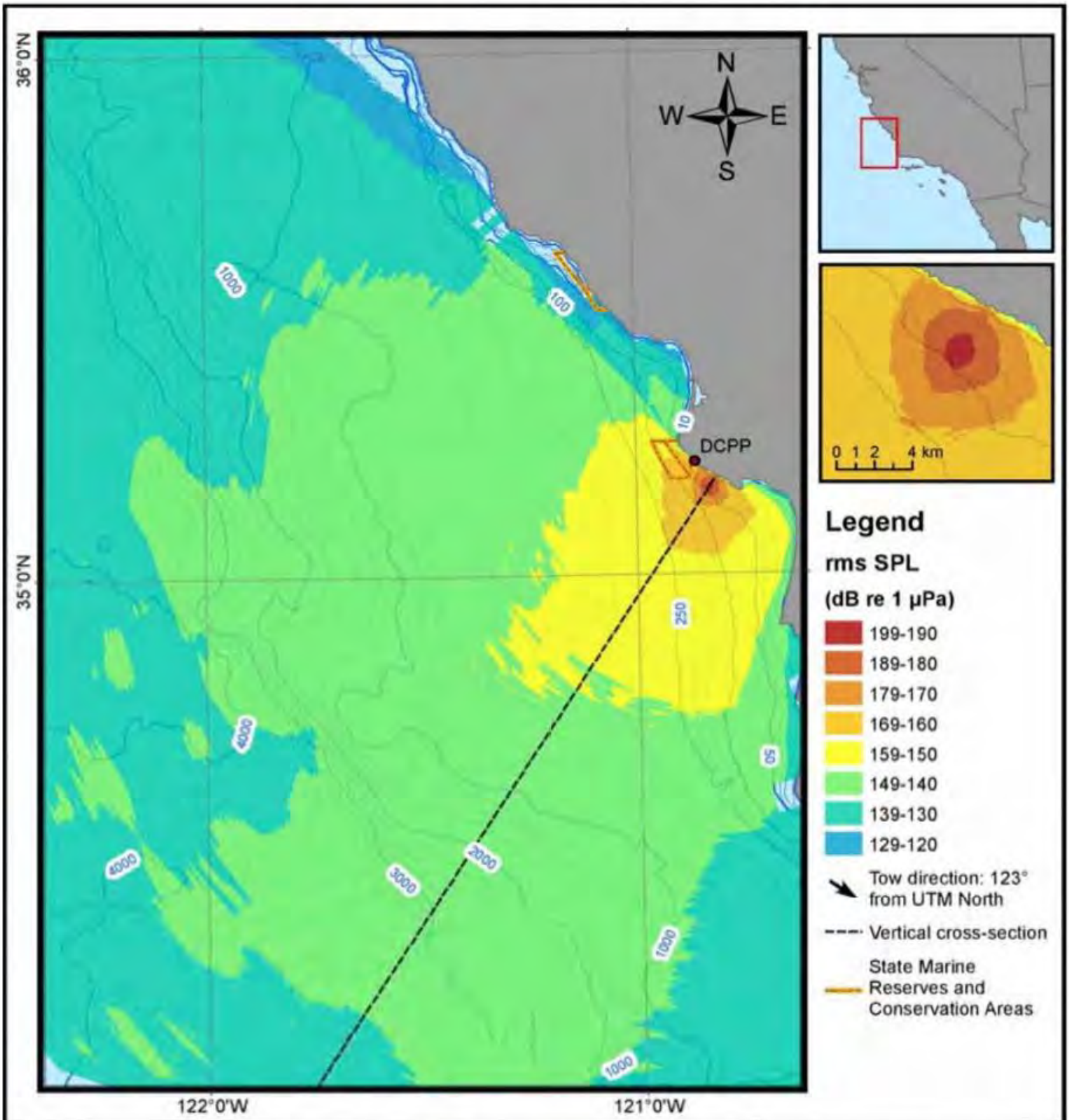

Bay National Marine Sanct
Two Highest Levels
of Impact Area
Santa Maria River Mouth
101
5
Channel Islands
National Marine Sanctuary
San Miguel Island
Santa Cruz Island
Anacapa Island
Santa Rosa Island
an Area In Need
of Protection
73 km
Image U.S. Geological Survey
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2010 Google
© 2010 Europa Technologies
©2009
Mar 31, 2008 – Jun 10, 46682
34°43'32.87" N 120°27'46.49" W elev 197 m

Figure 4.11-5 Example of Modeled Sound Pressure Levels from Air Gun Operations (Plan View)



Description: Modeled sound field (185 km) for the operation of the 3300 in³ airgun array, located at Site 8.

km
0 7.5 15 30 45

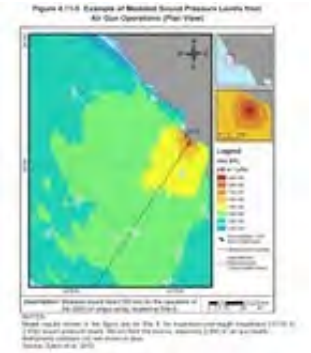
NOTES:
Model results shown in the figure are for Site 8, for maximum-over-depth broadband (10 Hz t
2 kHz) sound pressure levels 185 km from the source, assuming 3,300 in^3 air gun levels.
Bathymetry contours (m) are shown in blue.
Source: Zykov et al. 2012.

ITP Goldstein <itp.goldstein@noaa.gov>

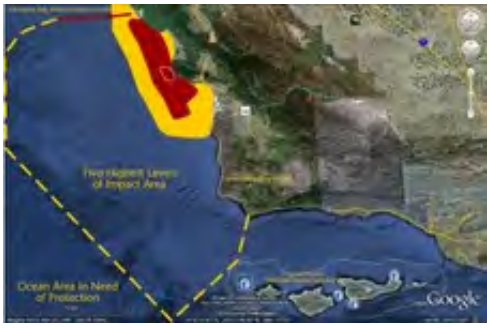
reposne to PG&E seismic testing proposal

Ruth & Karl Kempton <nrview@thegrid.net> Sun, Oct 14, 2012 at 1:37 PM
To: ITP.Goldstein@noaa.gov
Cc: Cassidy.Teufel@coastal.ca.gov, fmecham@co.slo.ca.us, bgibson@co.slo.ca.us, adam hill <ahill@co.slo.ca.us>, pteixeira@co.slo.ca.us, jpatterson@co.slo.ca.us

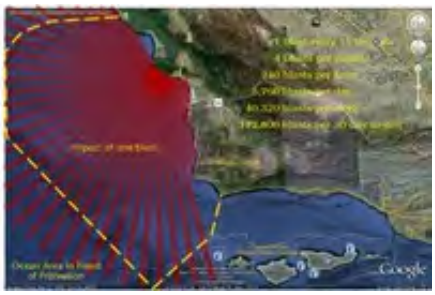
9 attachments



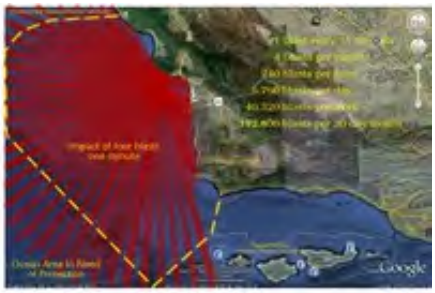
1-eir blast map.JPG
622K



3-2 higherst levels of blasting impacts.jpg
828K



***one blast impact.jpeg**
1216K



***four blast impact.jpeg**
1273K

***forty blast impact.jpeg**
950K

letter to Mr. Payne re pg&e seismic test.doc
43K

letter to Mr. Payne re pg&e seismic test.pages
184K

letter to Mr. Payne re pg&e seismic test.pdf
69K

CCC_CommentsSeismicSurveys.pdf
282K

P. Michael Payne
Chief Permits & Conservation Division
Office of Protected Resources
1315 East-West Highway
Silver Spring, Md. 20910
ITP.Goldstein@noaa.gov.

Karl Kempton
2740 Grell Lane
Oceano Ca 93445
nrview@thegrid.net

October 13, 2012

Dear Mr. Payne,

I am currently the lead researcher for the California Central Coast Marine Sanctuary Alliance. I was the lead ocean protection individual for the Environmental Center of San Luis Obispo from 1991 through 2005. As a former energy planner for the County of San Luis Obispo, I was hired to write the documentation for and promote the proposed Central Coast Marine Sanctuary.

I and others have many concerns regarding understated and false assumptions in PG&E's Final Environmental Impact Report for the proposed Central Coast seismic imaging project that was certified by the California State Lands Commission on August 20, 2012. A major concern is that the document prepared by NSF and the EA prepared by Padre Associates, Inc. both contradict the high levels of 'take' forecasted by both the DEIR and EIR by stating that there will not be significant impact on the environment.

How do you reconcile the conflict between these documents regarding significant and insignificant impacts to mammals?

While the document prepared by NSF states in its conclusion, "NSF has reviewed and concurs with the conclusions of the Environmental Assessment report prepared by Padre Associates, Inc. that implementation of the proposed activity **will not** have a

significant impact on the environment.", I will be directing my comments to the PG&E DEIR and EIR that understate rates of 'take'. Of the many concerns, I will limit myself to 1) referenced sonic tests, 2) web of life, and 3) impact on federally protected marine designations: two national marine sanctuaries, a national estuary and a national monument. By discussing these concerns, it follows at the same time that the NSF document and the EA both extremely understate 'take' and the significant impact on the environment.

1) Reference Sonic Tests

Perhaps the most glaring false assumption, in my opinion as a former statistician, is the use of various sonic research papers and conclusions to forecast the numbers of 'take' for various mentioned and unmentioned marine life species, especially mammals. The sited studies, statistically speaking, are not in the same 'statistical universe' as the proposed seismic imaging project. The proposed intensities and durations of the sonic waves exponentially far exceed any sited study or studies; they are unprecedented in scope compared to any referenced study. Thus, the predictive model is useless other than a significantly understated guess.

How can your agency allow such a glaring statistical variance to go unnoticed and uncommented upon?

Moreover, the draft EIR and final EIR ignored in their approaches the conflict between the federal government's assumed lower standards or assumptions of sonic impacts to marine life, especially mammals and those of the California Coastal Commission that are significantly higher. The differences between these two standards are of statistical significance.

How is your agency addressing this conflict?

2) Web of Life

The EIR admits that it has no actual scientific knowledge about the impact of the sonic blast waves on planktonic life forms. These are part of the foundation of the web of life for our near and offshore waters. Further, the DEIR and EIR never mentioned nor addressed the concept of the web of life and thus how the sonic blast waves would alter the feeding patterns of all marine life within the immediate and adjacent impact zones. Mammals, both migrating and living in these coastal waters depend on marine web of life food.

How can your agency allow this testing with the EIR admitting it has no actual knowledge on the impacts of the sonic blast waves on planktonic life forms?

How can your agency allow this testing while the EIR omits discussion on the impacts of the sonic blast waves on the web of life?

It has been documented that the lower intensity sonic testing that began over three weeks ago has altered the population patterns of the sea birds. Apparently, the fish that the cormorants, Brown Pelicans (endangered specie) and others depend upon for food have removed themselves from as far south as Pt. Purisma to at least Shell Beach. The rocks along Shell Beach are essentially void of sea birds. Morro Rock is also void of Brown Pelicans (endangered specie). This is the time of year when the Brown Pelican (endangered specie) population is the most dense in our county. It is documented that the Brown Pelican (endangered specie) population is now greater than usual in Cambria (within the Monterey Bay National Marine Sanctuary) and the Morro Bay National Marine Estuary, both federal programs protecting marine life.

Since the low sonic testing began over three weeks ago, fishermen are reporting unusual patterns. They have reported lack of marine life around Pt Purisma and lack of seabirds in large numbers on

rocks. Their catch has been cut in half, but PG&E will not mitigate their losses. They are catching large bottom fish in shallow not deep waters.

Also, there is documentation concerning sea lions. Within the Morro Bay National Marine Estuary an unusual number of sea lions have taken refuge from the sonic waves.

If marine mammals are hiding from this low sonic testing, what will take place with exponentially far higher sonic blast waves?

What will happen to the marine mammal food sources that are scattered by the exponentially far higher sonic blast waves?

3) Impact on Federally Protected Marine Designations: Sanctuaries, an Estuary and a National Monument

The DEIR and EIR impact maps show a large enough radius that the Monterey Bay National Marine Sanctuary, the Channel Islands National Marine Sanctuary and the Morro Bay National Marine Estuary will be impacted. Neither the DEIR nor the EIR referenced the Monterey Bay National Marine Sanctuary and the Channel Islands National Marine Sanctuary study documents for sanctuary protection expansion into the nearshore and offshore waters between them off San Luis Obispo County and western Santa Barbara County. The waters north of Point Sal were part of a marine sanctuary nomination before Congress in 1991 and 1992. Thus, it is known, but unmentioned in the DEIR and EIR, that these nearshore and offshore waters are of national and international significance due to the diversities and densities of marine life.

Also the DEIR and EIR fail to mention the California Coastal National Monument. As you know, this protects sea life whose habitat includes the nearshore rocks along the entire coast of California. There are prohibitions against approaching these rocks

within 100 feet so as not to disturb sea life resting or living on these rocks. There are fines for those ignoring these rules.

How can your agency permit the 'taking' of marine life, especially mammals, in two national marine sanctuaries, a national estuary and a national monument?

Therefore, based on review of the project description and relevant literature, the project is not eligible for an Incidental Harassment Authorization pursuant to the Marine Mammal Protection Act (MMPA), because impacts will not be limited to Level B harassment of marine mammals, but will in fact result in significant *Level A* take of marine mammals.

For a full response to the proposed PG&E seismic imaging project, see

<http://www.slocoastjournal.com/docs/archives/2012/june/pages/marine_sanctuary.html>

<http://slocoastjournal.com/docs/archives/2012/sept/pages/marine_sanctuary.html>

<http://slocoastjournal.com/docs/marine_sanctuary.html>

Sincerely,

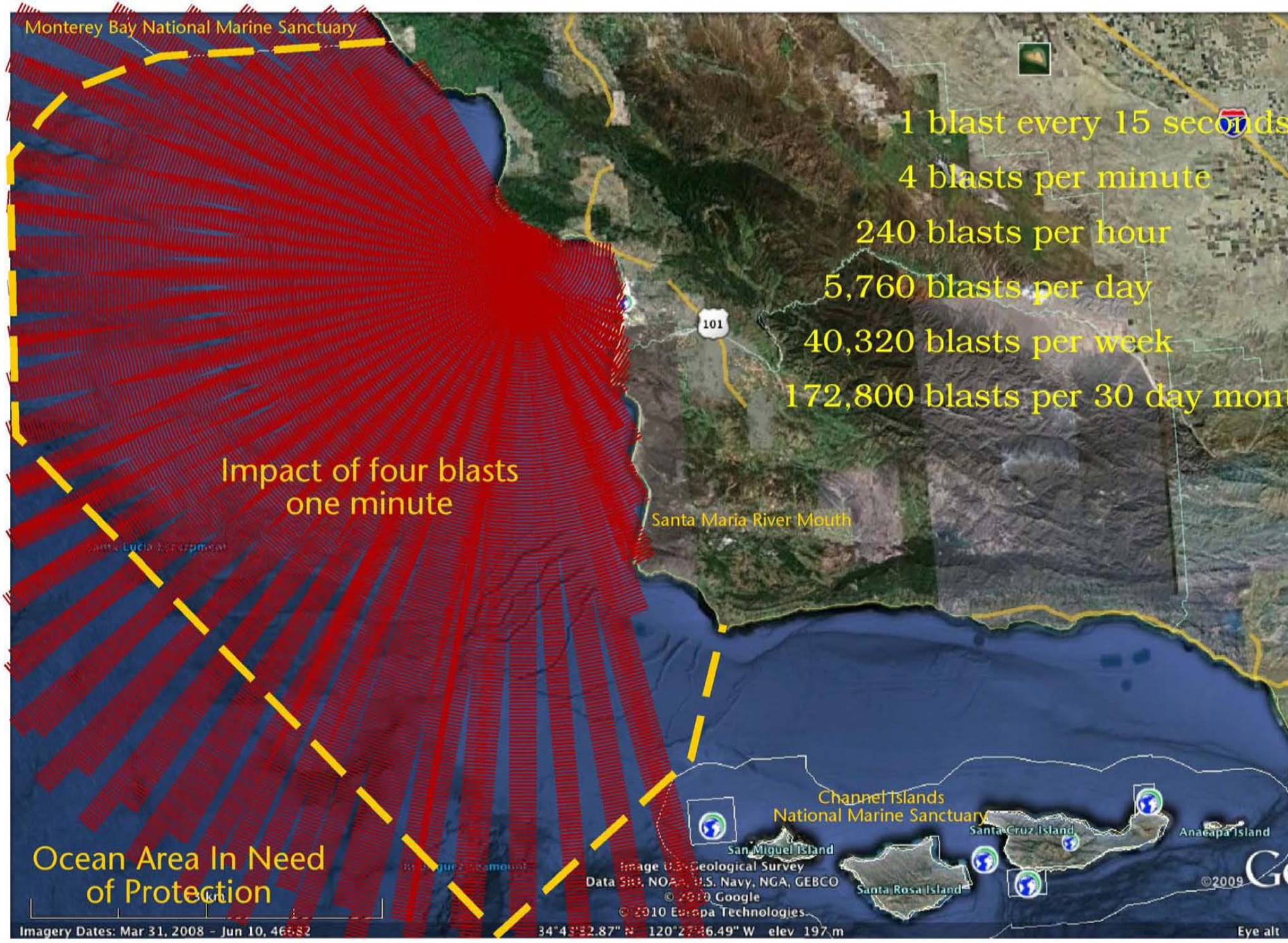
Karl Kempton

attachments
5 maps related to seismic testing proposal
California Coastal Commission Comments on Seismic Surveys

cc

Cassidy Teufel
California Coastal Commission
Energy, Ocean Resources and
Federal Consistency Division
Cassidy.Teufel@coastal.ca.gov

San Luis Obispo Country Board of Supervisors
District 1 Frank Mecham
fmecham@co.slo.ca.us
District 2 Bruce Gibson
bgibson@co.slo.ca.us
District 3 Adam Hill
ahill@co.slo.ca.us
District 4 Paul Teixeira
pteixeira@co.slo.ca.us
District 5 James Patterson
jpatterson@co.slo.ca.us


Monterey Bay National Marine Sanctuary
1 blast every 15 seconds
4 blasts per minute
240 blasts per hour
5,760 blasts per day
40,320 blasts per week
172,800 blasts per 30 day mont
101
Impact of four blasts
one minute
Santa Maria River Mouth
Channel Islands
National Marine Sanctuary
San Miguel Island
Santa Cruz Island
Santa Rosa Island
Anacapa Island
Ocean Area In Need
of Protection
Image U.S. Geological Survey
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2010 Google
© 2010 Europa Technologies
©2009
Imagery Dates: Mar 31, 2008 – Jun 10, 4658
34°43'32.87" N 120°27'46.49" W elev 197 m
Eye alt

ITP Goldstein <itp.goldstein@noaa.gov>

Public Comment for Seismic Testing

Ryan Lawler <trapshooter15@gmail.com> Sun, Sep 30, 2012 at 2:46 AM
To: ITP.Goldstein@noaa.gov

Hello,

Please go ahead and issue the IHA Marine Mammal Harassment permits for the seismic testing. I believe that assessing the risk of a nuclear meltdown is a fair trade off for Level B Harassment of marine mammals. Please do not obstruct the project with the needless burden of your bureaucracy.

Thank you

Please submit this comment as anonymous.

ITP Goldstein <itp.goldstein@noaa.gov>

(no subject)

Sandy Kavoyianni <sankavo1@hotmail.com> Sun, Oct 14, 2012 at 6:03 PM
To: ITP.Goldstein@noaa.gov

Killing all this mamals makes you murderers; of course for you we are all so idealist wanted them to LIVE!!!!!

ITP Goldstein <itp.goldstein@noaa.gov>

PG&E seismic testing

Sharon Moran <smoran1945@sbcglobal.net> Thu, Sep 20, 2012 at 7:20 PM
To: ITP.Goldstein@noaa.gov

Dear Mr. Goldstein,
I am writing to express my disagreement and disapproval of the seismic testing PG&E is planning in the waters off the central coast of California. The potential destruction to marine life, especially whales and dolphins, is not acceptable. The loss of revenue to fishermen could be huge. Businesses that rely on whale watching tourism will suffer I am appalled our the government leaders have approved this plan, and the way it was railroaded through without letting the opposition speak smells of behind closed doors agreements. It is unlikely it will help Diablo Canyon Nuclear Power Station prepare for the eventual earthquake that will devastate it in the same way as Fukushima. And it is not if there will be an earthquake but when. Please reconsider the approval of this destructive plan and rescind it immediately. Dismantle Diablo Canyon and put the money in solar or wind power.
Sincerely,
Sharon Moran

ITP Goldstein <itp.goldstein@noaa.gov>

Comments onTakes Of Marine Mammals Incidental to Geophysical Survey off California

Sharon Young <syoung@humanesociety.org> Sat, Oct 13, 2012 at 7:26 PM
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>
Cc: "michael.payne@noaa.gov" <michael.payne@noaa.gov>

Attached please find our comments on the application for incidental takes of marine mammals as a consequence of geophysical surveys sponsored by Pacific Gas and Electric. Please let me know if you have questions.

Regards,

Sharon B. Young

Marine Issues Field Director

The Humane Society of the United States

syoung@humanesociety.org<mailto:syoung@humanesociety.org>

508-833-0181

humanesociety.org<http://www.humanesociety.org/>

Join Our Email List<https://secure.humanesociety.org/site/SSurvey?SURVEY_ID=2820&ACTION_REQUIRED=URI_ACTION_USER_REQUESTS> Facebook<http://www.facebook.com/profile.php?id=6041057841> Twitter<http://twitter.com/HumaneSociety> Blog<http://hsus.typepad.com/wayne/>
[Description: Description: Description: Description: The Humane Society of the United States - Celebrating Animals | Confronting Cruelty]

California Seismic comment.pdf
388K

THE HUMANE SOCIETY
OF THE UNITED STATES

Eric L. Bernthal, Esq.
Chair of the Board

Jennifer Leaning, M.D., S.M.H.
Vice Chair

Kathleen M. Linehan, Esq.
Board Treasurer

Wayne Pacelle
President & CEO

Michael Markarian
Chief Program & Policy Officer

Laura Maloney
Chief Operating Officer

G. Thomas Waite III
Treasurer & CFO

Andrew N. Rowan, Ph.D.
Chief International Officer
& Chief Scientific Officer

Roger A. Kindler
General Counsel
Vice President & CLO

Janet D. Frake
Secretary

DIRECTORS

Jeffrey J. Arciniaco
Eric L. Bernthal, Esq.
Michael J. Blackwell, D.V.M., M.P.H.
Jerry Cesak
James Costos
Anita W. Coupe, Esq.
Neil B. Fang, Esq., CPA
Jane Greenspun Gale
Cathy Kangas
Jonathan D. Kaufelt, Esq.
Paula A. Kislak, D.V.M.
Jennifer Leaning, M.D, S.M.H.
Kathleen M. Linehan, Esq.
John Mackey
Mary I. Max
Patrick L. McDonnell
Judy Ney
Sharon Lee Patrick
Judy J. Peil
Marian G. Probst
Jonathan M. Ratner
Joshua S. Reichert, Ph.D.
Walter J. Stewart, Esq.
Andrew Weinstein
Jason Weiss
David O. Wiebers, M.D.
Lona Williams

P. Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910.
Submitted via: ITP.Goldstein@noaa.gov

October 13, 2012

RE: Takes Of Marine Mammals Incidental to Marine Geophysical Survey off the Central Coast of California, November to December 2012. [77 Fed. Reg. 58256, September 19, 2012]

Dear Mike,

On behalf of the more than 11 million members and supporters of The Humane Society of the United States (The HSUS), I am writing to express our concerns with your proposal to issue an Incidental Harassment Authorization (IHA) to Pacific Gas and Electric (PG&E) for the incidental take of twenty five species of marine mammals in the coming two months of this year. While we understand the need to assure structural integrity in areas around coastal nuclear power facilities, we are concerned with the risk posed by the current survey design to vulnerable marine mammal species. In particular we are concerned with impacts to the Morro Bay stock of harbor porpoise. The HSUS believes that you should consider permitting only the project currently before the California Coastal Commission for their consideration. The HSUS is also concerned that the sound levels that are generated and received may be inappropriately risk prone and that the consequences of displacement from the large ensonified area may not have been given sufficient weight. And, finally, we are concerned that activities are scheduled to start within 2 weeks (November 1, 2012) of the close of the meager comment period which itself is less than 30 days in length.

Concerns with Impacts from Sound Levels

The proposal, which involves the use of underwater airgun arrays will produce sonic blasts at 250 dB approximately every 15 seconds [FR at 58259] with sonic blasts occurring 24 hours a day for 7 days a week (FR at 58257 and 58258). At distances that would make night time detections impossible (e.g. one third of a mile), the received sound levels are predicted to exceed 180 to 190dB (FR at 58260). The NMFS has concluded that cetaceans should not be

exposed to levels exceeding 180 dB, a level at which permanent harm may accrue (e.g., NMFS 2000). The applicant predicts that, for the airgun array, the received level at 700 meters (approximately one third of a mile) will be 180 dB, [FR at 58260]. For the time when a single airgun will be in use, the distance at which 180 dB is the received level is much closer to the vessel. A single airgun is, oddly, being used for "mitigation." [FR at 58258]. It will operate constantly, providing at least one intense "shot" each minute even when the survey is not being actively undertaken (e.g., during turns or transits of less than 2 hours). [FR at 58277] The impact to marine mammals from the constant ensonification of their key or core habitat around the clock for weeks at a time must not be underestimated. Indeed, the MMPA requires that, when issuing an IHA, the authorization must include the "means of effecting the least practicable impact on" the species or stock to be taken. 16 U.S.C. § 1371(a) (5) (D) (ii) (I). A "mitigation" measure that is at the decibel level that NMFS believes can cause permanent harm to cetaceans and one that will operate constantly, firing at least one shot per minute, does not appear to meet this statutory standard.

Impacts to Protected Species

The NMFS acknowledges that at least 25 marine mammal species are likely to be affected by the proposed activity, including four Endangered Species Act (ESA) listed species: blue whales, fin whales, humpback whales, and California sea otters. However, little attention has been given to the possibility of affecting the Western Pacific stock of gray whales. Although Table 2 [FR at 58262] acknowledges that they may be present, there is little to no discussion of possible impacts to this critically endangered western stock, individuals of which have recently been documented venturing into the range of Eastern Pacific gray whales which are not listed under the ESA. (NOAA, 2012). As NMFS acknowledges in its Federal Register notice, because threatened and endangered species may be present in the action area, NMFS must engage in Section 7 consultation under the Endangered Species Act to evaluate the effects of granting the IHA, to ensure that if NMFS chooses to grant the IHA, the harassment to which the listed species will be subjected will not jeopardize their continued existence. 16 U.S.C. § 1536(a) (2). NMFS's failure to properly consult on the effects of its actions on all listed marine species that may be affected by the action would violate the ESA.

In addition, we are particularly concerned with impacts to the Morro Bay stock of harbor porpoises. The NMFS has acknowledged that they have a limited range extending only from Point Sur to Point Conception [FR at 58264]. This species is also acknowledged to respond more strongly to seismic operations than similar sympatric species [FR at 58267]. NMFS states that "the seismic airgun operations will ensonify a large area that reaches from land to offshore past where harbor porpoises are typically found. " [FR at 58288] Even when not within the range of dangerous noise levels, the NMFS acknowledges that "reactions at longer distances may be particularly likely when sound propagation conditions are conducive to transmission of the higher frequency components of airgun sound to the animals' location." [FR at 58267]

The proposed seismic operations will occur throughout a large portion of the range of the Morro Bay stock of harbor porpoises are acknowledged to "cover much of the core range and optimal habitat for this stock for the duration of the seismic survey." [FR at 58288] The NMFS makes the honest, yet damning admission that "[s]ighting rates outside of the operational area are much

Celebrating Animals | Confronting Cruelty

2100 L Street, NW Washington, DC 20037 t 202.452.1100 f 202.778.6132 humanesociety.org

lower, indicating sub-optimal habitat. Studies have shown that harbor porpoises are sensitive to underwater sound and will move long distances away from a loud sound source; and the Morro Bay stock may be forced to move to sub-optimal habitat at the ends of (North or South), or outside their normal range for days to weeks, which may affect foraging success which could in turn have energetic impacts that effect [sic] reproduction or survival." (FR at 58288)

This admission leads us to be concerned that, even if this activity does not result in immediate death or permanent hearing loss in this acoustically sensitive species, energetic costs that cannot be accurately assessed may impinge on subsequent reproductive success or delayed mortality resulting from nutritional stress. These sorts of effects may not be detected, as dead animals typically sink unless close to shore or may be carried out by tides. It is also doubtful that future effects on reproduction would be accounted. Additionally, though the timing seeks to avoid "the first few months that are critical to nursing mothers and dependent calves" (ibid.), young, newly weaned animals are not efficient foragers. Even if no longer nursing, if forced to compete with more competent adults for prey in a sub-optimal foraging area, they may not be able to be sufficiently successful to meet their energetic requirements. The loss of a substantial number of calves or young juveniles who die as a result of nutritional stress would not only be an immediate loss to the population, but would also represent a loss to the stock's future reproductive potential. As NMFS is well-aware, the MMPA only allows the authorization of incidental take if it will have no more than a "negligible impact" on the species or stock to be taken. 16 U.S.C. § 1371(a) (5) (D) (i). NMFS must fully consider these significant threats to the Morro Bay stock of harbor porpoises to ensure that the proposed activity will have no more than a negligible impact on the stock. If the activity will have more than a negligible impact, NMFS cannot authorize the take.

Finally, and most notably, in the Federal Register notice NMFS estimates that the proposed activity will result in the takes of over 1,500 harbor porpoises, which constitutes 59.2 – 74 percent of the entire population of the Morro Bay stock of harbor porpoises [FR at 58285]. Yet the MMPA only allows the issuance of IHA's for activities that will result in the take of "*small* numbers of marine mammals." 16 U.S.C. § 1371(a)(5)(D)(i) (emphasis added). It is hard to see how the take of *more than half* of an entire stock can ever be considered "small numbers." As such, NMFS cannot authorize the proposed activity in its current iteration without running afoul of the express requirements of the MMPA.

Inadequacies of Mitigation and Monitoring

The potential for adverse effects on this stock seem far more dramatic than the minimal mitigation and monitoring plan would address. A number of mitigation measures are proposed, but we have little confidence in their efficacy. Among measures proposed are "vessel-based" contingency plans, proposed exclusion zones around the sound source, power-down and shut-down procedures and adaptive management, mitigation and monitoring aimed specifically at the Morro Bay stock of harbor porpoises. [FR at 58275]

The proposed "exclusion zone" would rely on an observer detecting marine mammals within the zone that would in turn result in the crew immediately "powering-down" the array. The "power down" procedure simply requires the vessel to decrease the number of airguns to one such that

Celebrating Animals | Confronting Cruelty

2100 L Street, NW Washington, DC 20037 t 202.452.1100 f 202.778.6132 humanesociety.org

"the radius of the 180 dB zone is decreased to the extent that the observed marine mammal(s) are no longer in or about to enter the exclusion zone for the full array." [FR at 85276] Thus the intense sound from a single airgun is used as "mitigation" for even more intense sound generated by the full array. The radius of the 180 dB area extends to one third of a mile. This means that detecting a single harbor porpoise about to enter that area would be difficult in daytime and impossible at night.

To address times of limited visibility, the mitigation measure offered is simply that, when the full area is not visible to an observer (e.g. at night or in the fog), there will be no ramp-up of the full array until one airgun has been operating for a sufficient length of time to, in effect, drive animals far from the source vessel and immediate harm. [FR at 58277] The assumption is that the operation of this single airgun assures that marine mammals "will be alerted to the approaching seismic vessel…and could move away." [ibid] Given the range at which the sound propagates this may seem reasonable as a means to prevent immediate and permanent hearing damage and/or loss of life. However, this merely mitigates a short-term risk of immediate harm. The harm that needs to be mitigated must also include the fact that, as a result of the survey activities, harbor porpoise will likely "*be forced to move…outside their normal range for days to weeks*." [FR at 58288] But there is no mitigation for the fact that they will be *forced to move* from key foraging habitat and into "sub-optimal" areas for prolonged periods, placing them at high risk for nutritional stress and delayed or ancillary consequences.

The mitigation that is said to be specific to porpoises includes pre-survey aerial surveillance, visual monitoring by on-board observers (who, as previously noted, are unlikely to see porpoises at a distance of one third of a mile in daylight and unlikely to see them at all at night). Suspension would be triggered if there are "unusual behaviors" observed (e.g., bunching in large groups). Further, a stranding response plan will be put in place. Suspension of activities is said to be triggered in the even a mass stranding occurs; or if several individuals of one or more species strands within a short span of time (e.g. 2 cetaceans in a single day or 3 in a week etc.). However, we note that, depending on tides or currents, dead animals may not wash in to shore and may not be detected. A ship-strike of any marine mammal would also result in cessation of activities pending further investigation.

The mitigation plan for porpoises also states that activities would be suspended in the event that surveys show that "moderate to large numbers of the Morro Bay stock of harbor porpoises have been pushed from their primary (core) habitat and/or outside of their normal stock range." (FR at 58278] It is not apparent what number of animals is considered "moderate to large." This should be better defined. Indeed, the MMPA requires that any IHA include the "means of effecting the least practicable impact on" the species or stock to be taken. Id. § 1371(a)(5)(D)(ii)(I). Accordingly, if NMFS approves the IHA, it must include additional mitigation measures to ensure the activity will have the least practicable impact on each marine mammal species or stock that would be affected by the proposed activity.

Concerns with the Appropriateness of Issuing an Incidental Harassment Permit

The NMFS has acknowledged that porpoises may be driven from core foraging habitat and that this may result in reduced viability of individual animals, as well as resulting in longer-term

Celebrating Animals | Confronting Cruelty

2100 L Street, NW Washington, DC 20037 t 202.452.1100 f 202.778.6132 humanesociety.org

effects on reproductive fitness. In the Federal Register, there is discussion that anticipates that mortality may occur. As a result of the likelihood of either immediate or longer-term mortality that may not be detected, it seems inappropriate to issue an IHA on the assumption that only "level B" harassment is likely to occur. Indeed, the process through which NMFS has proposed to authorize the incidental taking that will occur from PG&E's action specifically only applies to "the incidental… *taking by harassment of* small numbers of marine mammals…" 16 U.S.C. § 1371(a)(5)(D)(i) (emphasis added). Harassment is defined as "any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including but not limited to, migration, breathing, nursing, breeding, feeding or sheltering." Id. § 1362(18)(A). It does not include acts that result in mortality of marine mammals. As such, NMFS cannot authorize any activity that will result in mortality through the expedited process that exists only for authorizing incidental harassment.

Further, as mentioned above, the public comment period for this permit application for a very controversial project is less than one month in length. Yet, the MMPA expressly requires that NMFS request public comment on a proposed authorization "through notice in the Federal Register… *for a period of 30 days after publication*." 16 U.S.C. § 1371(a)(5)(D)(iii) (emphasis added). The Federal Register notice of the opening of public comment was published on September 19, 2012 and closes on October 15, 2012, which is less than the 30 days mandated by the statute. It is disturbing that NMFS did not comply with this statutory requirement that exists to ensure the public can fully participate in the agency's decision-making and that the agency will have before it all relevant information. Moreover, the Federal Register indicates that proposed activities would commence on November 1, 2012; only 2 weeks after the close of public comment. This gives the appearance that the agency has already determined the outcome. The short amount of time between the close of public comment and the start of activities provides insufficient time for the agency to amend mitigation and monitoring protocols or to affect the design or conduct of the proposed activities.

An Environmental Impact Statement (EIS) Should Have Been Prepared

Finally, NMFS should have prepared an EIS on this proposed action, rather than a more cursory Environmental Assessment (EA). The National Environmental Policy Act ("NEPA") requires federal agencies to prepare a detailed Environmental Impact Statement (EIS) for any "major federal action significantly affecting the quality of the human environment." 42 U.S.C. § 4332(2)(C). NEPA evaluation must take place "before decisions are made and before actions are taken." 40 C.F.R. § 1500.1(a) (emphasis added). Such an approach ensures that agencies will take the requisite "hard look" at environmental consequences before approving any major federal action. Kleppe v. Sierra Club, 427 U.S. 390, 410, n. 21 (1976). "It is only when the proposed action "will not have a significant effect on the human environment," 40 C.F.R. § 1508.13 (emphasis added), that an EIS is not required." National Audubon Soc. v. Hoffman 132 F.3d 7, 13 (2nd Cir. 1997). Wherever a question exists as to whether an EIS is required, an agency must ordinarily at least prepare an EA, which is used to determine whether the environmental effects of the action are "significant" and therefore require the preparation of an EIS. 40 C.F.R. § 1501.4. An EA is "a concise public document that briefly provides evidence and analysis for determining whether to prepare an EIS or a finding of no significant impact." Id. at § 1508.9.

Celebrating Animals | Confronting Cruelty

2100 L Street, NW Washington, DC 20037 t 202.452.1100 f 202.778.6132 humanesociety.org

Similar to an EIS, an EA must contain a description of the purpose and need of the proposed action, an analysis of the environmental effects of the proposed action, as well as a range of reasonable alternatives and the environmental effects of such alternatives. Id. at § 1508.9(b).

The Council on Environmental Quality (CEQ) has promulgated regulations implementing NEPA that are "binding on all Federal agencies." 40 C.F.R. § 1500.3. These regulations instruct that whether an action will have a "significant" impact on the environment, thus warranting the preparation of an EIS, requires considerations of both "context" and "intensity."1 40 C.F.R. § 1508.27. The presence of any one of CEQ's "significance" factors "should result in an agency decision to prepare an EIS." Pub. Serv. Co. v. Andrus, 825 F.Supp. 1483, 1495 (D. Idaho 1993); see also See LaFlamme v. FERC, 852 F.2d 389, 398 (9th Cir.1988). If "substantial questions as to whether a project. . .may cause significant degradation of some human environmental factor," an EIS must be prepared. Idaho Sporting Congress v. Thomas, 137 F.3d 1146, 1149 (9th Cir. 1998). Here, a number of significance factors are present such that NMFS should have prepared an EIS.

First, NMFS must prepare an EIS because the proposed action threatens a violation of the MMPA and its implementing regulations—federal laws imposed to protect the environment. See 40 C.F.R. § 1508.27(b)(10) (in determining the significance of a proposed action's effects on the environment, an agency must evaluate "[w]hether the action threatens the violation of a Federal, state or local law…imposed for the protection of the environment."). Second, in determining whether an action is significant, CEQ regulations also require an agency to consider "[t]he degree to which the effects. . . are likely to be highly controversial." 40 C.F.R. § 1508.27(b)(4). "Controversial" is "a substantial dispute [about] the size, nature or effect of the major Federal action." Blue Mountains Diversity Project v. Blackwood, 161 F.3d 1208, 1212 (9th Cir. 1998) (citations omitted). A substantial dispute exists when evidence, raised prior to the preparation of an EIS or FONSI casts serious doubt upon the reasonableness of an agency's conclusions. Protect Our Water v. Flowers, 377 F. Supp.2d 844, 861 (E.D. Cal. 2004). "[A]n outpouring of public protest" has been held to satisfy the requirement of "substantial dispute." Greenpeace Action v. Franklin, 14 F.3d 1324, 1334 (9th Cir.1992). Once a substantial controversy arises, NEPA places a burden on the agency to come forward with a "well reasoned explanation" demonstrating why those responses do not suffice to create a public controversy. LaFlamme, 852 F.2d at 401. Next, the action will occur near the California coast – an ecologically significant area that contains a multitude of cultural resources. 40 C.F.R. § 1508.27(b)(3). Finally, as indicated above the action will have significant impacts a variety of marine life, including harbor porpoises and may adversely affect threatened and endangered species, both of which trigger NMFS's duty to prepare an EIS under CEQ's regulations. Id. § 1508.27(b)(1), (9). NMFS's failure to prepare an EIS in light of the presence of so many significance factors would violate its mandatory duties under NEPA.

Conclusion

A further concern is that, the California Coastal Commission is not scheduled to consider the PG&E application and the possibility of a consistency determination until its November meeting, which is after the scheduled start of the proposed surveys. We believe that the NMFS should not consider granting any proposal that may differ from that before the California Coastal

Celebrating Animals | Confronting Cruelty

2100 L Street, NW Washington, DC 20037 t 202.452.1100 f 202.778.6132 humanesociety.org

Commission, and we understand that PG&E has submitted a substantially different proposal to the Commission for consideration.

We believe that the NMFS cannot authorize this activity at this time given the severity of impact, the inadequate mitigation and the procedural shortcomings apparent in this permitting process. Additionally, the applicant and NMFS should consider the use of newer, alternative technologies that may be less likely to subject marine mammals to this level of adverse impacts.

Sincerely,

Sharon B. Young
Marine Issues Field Director
The Humane Society of the United States
syoung@humanesociety.org

References Cited

NMFS. 2000. Small takes of marine mammals incidental to specified activities; marine seismic-reflection data collection in southern California/Notice of receipt of application. 65 Federal Register 16374-16379, March 28, 2000

NOAA, 2012. Safe Passage, NOAA Scientists and Gray Whale are Forging New Paths. NOAA Fisheries Service. Story Posted April 22, 2012. Available at: http://www.nmfs.noaa.gov/stories/2012/04/4_22_12our_earth_our_animals.html

Celebrating Animals | Confronting Cruelty

2100 L Street, NW Washington, DC 20037 t 202.452.1100 f 202.778.6132 humanesociety.org

ITP Goldstein <itp.goldstein@noaa.gov>

The pollution and destruction you place upon this earth!

Soledad Herrera <colourmetoo@gmail.com> Sun, Oct 14, 2012 at 7:00 PM
To: ITP.Goldstein@noaa.gov

Hello Dear Marine people.
I cannot believe that today still people are running around killing everyone and anyone.
How can you continue to do this!..please stop the destruction on the very home that supports your life...please have some respect for this world that you so willing destruct..
Please stop!

Soledad

--

Soledad Herrera
www.colourmetoo.com.au

> *Constant kindness can accomplish much. As the sun makes ice melt, kindness causes misunderstanding, mistrust, and hostility to evaporate.*
> ***Albert Schweitzer***

ITP Goldstein <itp.goldstein@noaa.gov>

Seismic testing

Starla Martin <therealstarla@icloud.com> Tue, Oct 16, 2012 at 5:25 PM
To: "ITP.Goldstein@noaa.gov" <ITP.Goldstein@noaa.gov>

Attention: P.Michael Payne, Chief Permits & Conservation Division
Office of Protected Resources National Maritime Fisheries svc
Gentle people:
This testing is known to hurt or even kill Whales and Dolphins probably many other life forms.
Many people have stated this fact. Common sense tells everyone.
Do not allow this to happen. Please.
Sincerely,
Starla Martin
3905 Pinell St
Sacramento, CA 95838
916-813-0024
Therealstarla@icloud.com

Sent from my iPhone

DATE: 20 SEPTEMBER 2012

TO: NOAA, NATIONAL MARINE FISHERIES SERVICE

FROM: STEPHEN SMITH (805) 835-6689
402 MONTEBELLO OAKS DRIVE
PASO ROBLES, CA 93446

PLEASE DO NOT APPROVE PG&E'S PLAN TO DO SEISMIC TESTING IN THE OCEAN OFF OF THE DIABLO CANYON POWER PLANT.

TOO MUCH OF OUR MARINE LIFE WILL BE KILLED.

AB1632 DOES NOT REQUIRE THIS TYPE OF TESTING.

THERE ARE OTHER NON-INVASIVE METHODS TO USE THAT WILL PRODUCE BETTER RESULTS. SCRIPPS INSTITUTE OF OCEANOGRAPHY HAS PROPOSED ELECTRO-MAGNETIC STUDIES.

THANK YOU FOR PROTECTING OUR MARINE ENVIRONMENT.

09-05-12
PRI

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Stop the Diablo Canyon Seismic Testing

Howard Goldstein <howard.goldstein@noaa.gov> Mon, Oct 15, 2012 at 7:02 PM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Stephen Smith** <stephen.denton.smith@gmail.com>
Date: Mon, Oct 15, 2012 at 6:56 PM
Subject: Stop the Diablo Canyon Seismic Testing
To: Howard.Goldstein@noaa.gov

Dear Mr. Goldstein,

Because the beginning parts of this project having been allowed to go ahead, i.e. the tagging of sea otters, without going through the appropriate approval process and the areas to be studied have been scaled down, the seismic studies will be of marginal benefit. The cost to marine life and the local economic devastation out weights the benefit of these seismic studies. The NRC has declared that the Diablo Canyon is safe, so the seismic studies are unnecessary. Also, the whales are threatened and endangered already, and don't need to be harassed or worse. PG&E has stated they will make no plant upgrades regardless of the seismic results, so seismic testing does nothing to improve our safety. Finally, Morro Bay is the core home of the species of Harbor Porpoises and Otters. They could be rendered completely extinct in this area if this unnecessary seismic testing is allowed to go forward.

Signed,

Stephen D. Smith

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

NOAA FISHERIES

ITP Goldstein <itp.goldstein@noaa.gov>

Comment on Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Stranded No More <strandednomore@gmail.com> Mon, Oct 15, 2012 at 9:05 PM
To: ITP.Goldstein@noaa.gov

To:
P. Michael Payne,
Chief, Permits and Conservation Division,
Office of Protected Resources,
National Marine Fisheries Service,
1315 East-West Highway, Silver Spring, MD 20910.
October 15, 2012

From: StrandedNoMore

Dear Mr. Payne,

We are deeply concerned about the recent proposal submitted by the Lamont-Doherty Earth Observatory of Columbia University (L-DEO), in cooperation with the Pacific Gas and Electric Company (PG&E) outlining their intent to conduct Marine Geophysical Survey off the Central Coast of California, November to December, 2012. We believe the proposal significantly downplays possible effects of such activities and omits important scientific information that is currently available. We urge NMFS to deny this application.

1. We believe that based on available scientific data the application should have included Level A harassment in addition to Level B harassment. There have been at least two documented cases and over a dozen of anecdotal evidences that linked seismic surveys to strandings and death of cetaceans worldwide. Recently (August and September 2012), there have been numerous live strandings including 33 stranded cetaceans in the UK and all these strandings coincided in time and space with seismic surveys performed by various operators. Sadly, none of these strandings has been investigated in detail and no independent entity performed necropsies in search for possible evidence. In many cases necropsies were not even done. See Appendix 1 for all cases (investigated and accidental linking strandings to seismic surveys).
While the application cites one study linking seismic surveys to beaked whales strandings (Malakoff, 2002) it fails to cite another scientific report linking seismic surveys to beaked whales strandings in Galapagos Islands in 2002 (Gentry, 2002).

2. The application does not provide the most recent and crucial information on physiological response to anthropogenic noise exposure. According to the application marine mammals will be exposed to extremely loud sounds: 242 dB re 1 μPa for echosounder and up to 265 dB re 1 μPa for air guns. Recent study by Lyamin et al. (2011) indicated that beluga whale started showing extremely troubling physiological response at significantly lower levels: “Our data indicate that severe tachycardia developed in the beluga at lower noise intensities (as low as 140 dB); at higher intensities, the HR could reach a twofold excess over the control values and last for no less than 4 min” (p. 278). This study was not even mentioned in current application.

3. The application does not discuss how strandings could be behavioral response to anthropogenic noise and fails to cite two very important studies:

a) Nearstarnding of melon-headed whales in Hawaii (possibly caused by military sonar) which most likely was a behavioral response to anthropogenic noise (Brownell et al., 2009)
b) Review on how cetaceans have been historically hunted with sound and have been demonstrating strong avoidance of sounds that has a potential to lead to a stranding event (Brownell et al., 2008)

4. The application does not discuss recent evidence of a fin whale fleeing the earthquake that happened over 200 km away from the whale (Gallo-Reynoso et al., 2011). The fin whale showed accelerated speed and it was concluded that the sound of the quake induced severe reaction even at the very low levels (more than 200 km away from the source)

5. We have been observing strandings happening all over the world very close in space and time to seismic surveys and sadly detailed and independent investigation of these cases is non-existent. There are simply not enough specialists, resources or facilities to conduct detailed investigation that can implicate seismic surveys as the reason for stranding. For example, embolism testing that can indicate decompression sickness has to be performed within 24 after death. The reality is it rarely happens. Additionally, if in some cases strandings have been indeed behavioral responses, then linking seismic surveys to a stranding could be nearly impossible because cetaceans will not be showing any specific trauma or evidence.

There are too many unknown effects that the proposed seismic survey can cause that we urge NMFS to deny this application. It does not include important scientific information, it does not discuss newest data on physiological response to anthropogenic noise and it does not discuss strandings as behavioral response. The application does not outline what independent organizations will be investigating possible strandings, what funding will be available for such investigations and where this funding will be coming from (Wade et al., 2010; Weilgart et al., 2005).

Based on the information outlined above we strongly urge NMFS to deny this application.

Sincerely,
StrandedNoMore

References:

Brownell, R. L. et al., (2009), Behavior of melon-headed whales, Peponocephala electra, near oceanic islands, Marine Mammal Science, 25(3), 639-658. Available at http://cetus.ucsd.edu/Publications/Publications/BrownellMMS2009.pdf

Brownell, R.L. et al., (2008), Hunting cetaceans with sound: a worldwide review, J. CETACEAN RES. MANAGE. 10(1):81–88. Available at http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1086&context=usdeptcommercepub

Gentry, R. (2002), Mass Stranding of Beaked Whales in the Galapagos Islands, April 2000, Reports for NMFS, Available at http://www.nmfs.noaa.gov/pr/pdfs/health/galapagos_stranding.pdf

Lyamin O.I., Korneva, S.M., Rozhnov, V.V., Mukhametov, L.M. (2011), Cardiorespiratory Changes in Beluga in Response to Acoustic Noise, Doklady Biological Sciences, Vol. 440, pp. 275–278, 704-707. Available at http://beluga.sevin-expedition.ru/netcat_files/106/57/11_Lyamin_ECG_acoustic_noise_beluga_DAN_E.pdf

Malakoff, D. (2002), Suit Ties Whale Deaths to Research Cruise, Science,
Vol. 298 no. 5594 pp. 722-723, Available at http://www.sciencemag.org/content/298/5594/722.citation

Gallo-Reynoso, J.B., Egido-Villarreal, J., Martinez-Vallalba, G.L. (2011), Reaction of fin whales Balaenoptera physalus to an earthquake, Bioacoustics, 2011, 20, 317–330. Available at http://www.academia.edu/1198507/Reaction_of_fin_whales_Balaenoptera_physalus_to_an_earthquake

Wade et al., 2010, Conflict of interest in research on anthropogenic noise and marine mammals: Does funding bias conclusions? Marine Policy, 34, 320-327.

Weilgart L, Whitehead H, Rendell L, Calambokidis J. (2005), Signal-to-noise: funding structure versus ethics as a

solution to conflict-of-interest. Marine Mammal Science, 21:779–81

Appendix 1. Anecdotal evidences linking seismic surveys to strandings. These cases were either not investigated at all, or were not investigated by independent organizations.

1. Mozambique 2006 (http://www.iol.co.za/scitech/technology/seismic-float-twists-stranding-of-dolphins-1.301955)

2. Madagascar, 2008 (http://news.bbc.co.uk/2/hi/africa/7443559.stm)

3. Peru, 2012 (https://docs.google.com/file/d/0BzPA6tiYhZyhX1I6T1Q5MHZqd1U/edit?pli=1)

4. Interesting Statistics from Australia (2002-2004) (http://www.whales.org.au/strandings/oceania/index.html)

5. Iceland, 2012 (http://strandednomore.wordpress.com/2012/07/30/independent-investigation-of-mass-stranding-in-iceland-sure-enough-big-oil-has-been-doing-seismic-surveys-in-the-area/)

6. UK, 2012 (http://strandednomore.wordpress.com/2012/09/26/seismic-surveys-and-strandings-continue-in-the-uk-another-endangered-sei-whale-is-killed/)

7. Philippines, 2012 (http://strandednomore.wordpress.com/2012/09/20/september-2012-philippines-strandings-and-anthropogenic-noise-activities/)

ITP Goldstein <itp.goldstein@noaa.gov>

NO to seismic testing in CA

Tabashian@aol.com <Tabashian@aol.com> Sun, Oct 14, 2012 at 7:53 PM
To: ITP.Goldstein@noaa.gov

Please do NOT allow seismic testing off the California coast. Too many marine mammals will be harmed.

Thank you,

Tamara Abashian
Durham, NC

ITP Goldstein <itp.goldstein@noaa.gov>

No to seismic testing

Tara Conrad <tellurictara@gmail.com> Sun, Oct 14, 2012 at 10:40 PM
To: itp.goldstein@noaa.gov

I am against seismic testing of any sort. Stop Diablo Canyon from harming sea life!
Sent from my Windows Phone

ITP Goldstein <itp.goldstein@noaa.gov>

Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California, November to December, 2012

Taryn Kiekow <tarynkiekow@hotmail.com> Mon, Oct 15, 2012 at 8:50 PM
To: itp.goldstein@noaa.gov

Mr. Payne,

Attached please find comments regarding the request from Lamont-Doherty Earth Observatory, in cooperation with the Pacific Gas and Electric Company, for authorization to take marine mammals incidental to conducting a seismic survey of the coast of central California. These comments are being submitted on behalf of the Whales Need US coalition.

Best regards,
Taryn Kiekow

WNUS Diablo Canyon letter to NMFS (Oct 15 2012).pdf
71K

By Electronic Mail

October 15, 2012

P. Michael Payne, Chief
Permits and Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910

E-mail: ITP.Goldstein@noaa.gov

Re: *Takes of Marine Mammals Incidental to Specified Activities; Marine Geophysical Survey off the Central Coast of California, November to December, 2012*

Dear Mr. Payne:

On behalf of the undersigned organizations of Whales Need US, a coalition of environmental and conservation organizations representing tens of millions of members and activists, we write to express our opposition to the proposed marine geophysical survey off the central coast of California ("seismic survey"). We appreciate the opportunity to submit comments on the request from Lamont-Doherty Earth Observatory of Columbia University ("L-DEO"), in cooperation with the Pacific Gas and Electric Company ("PG&E"), to take marine mammals incidental to conducting the proposed seismic survey. *See* 77 Federal Register 58256 (September 19, 2012). For the reasons set forth below, however, we recommend that NMFS deny the requested Incidental Harassment Authorization ("IHA").

Although we support safety at the Diablo Canyon nuclear reactor in San Luis Obispo County – and understand the importance of assessing the earthquake risk at the plant given the disaster at the Fukushima Daiichi Nuclear Power Station last year – we cannot support the seismic survey. The seismic survey will have highly significant, unavoidable impacts on endangered and vulnerable marine mammals and on recently established marine protected areas. It will also affect a wide range of other species and the human communities that depend on ocean ecosystems.

As proposed, the seismic survey will not provide information that is either essential for assessing earthquake risk at the plant or likely to result in improvement in the plant's safety. It will, however, result in high environmental costs.

According to the Federal Register notice, the proposed seismic survey will impact over two dozen different species of marine mammals, including four endangered species: blue whales, fin whales, humpback whales, and California sea otters. It will also impact gray whales in the area. While the Eastern North Pacific gray whales are not listed as endangered, Western North Pacific gray whales – one of the most critically endangered species on the planet – could be impacted if a whale migrated early in the season. Although not addressed in the FEIR, recent studies have shown that Western North Pacific gray whales do migrate through these waters.[1]

The proposed seismic survey will also impact a small, discrete population of harbor porpoises that resides in and around Morro Bay. As NMFS acknowledges, harbor porpoises are acutely sensitive to man-made

[1] Oregon State University, Marine Mammal Institute, available at http://mmi.oregonstate.edu/Sakhalin2011.

sound, making them the most vulnerable both to habitat abandonment and to hearing loss. Given their dependence on sound for most life functions, this could destroy their ability to survive and reproduce. Although NMFS has prescribed specific mitigation with regard to harbor porpoises, the impacts from behavioral disruption – such as habitat abandonment and the interruption of breeding, nursing and feeding – could have long term consequences on the population.

In addition, the proposed seismic survey would have major impacts on fish and other non-mammal species. The seismic survey will also undermine the ecosystem protection and restoration goals of newly established marine protected areas (MPAs) in San Luis Obispo County, including the State Marine Reserve and State Marine Conservation Area at Point Buchon.

For all these reasons, we urge NMFS to deny the IHA.

We appreciate your consideration of this important issue.

Sincerely,

Susan Millward, Executive Director
Animal Welfare Institute

Hardy Jones, Executive Director
BlueVoice

William Rossiter, President
Cetacean Society International

David Phillips, Director, International Marine Mammal Project
Earth Island Institute

Allan Thornton, President
Environmental Investigation Agency

Mary Whitney, Founder/Director
Fluke Foundation

Phil Kline, Oceans Campaigner
Greenpeace USA

Tami Drake, Board Member
Green Vegans

Sharon Young, Marine Issues Field Director
The Humane Society of the United States

Scott Leonard, Director of Operations
Nantucket Marine Mammal Conservation Program

Peggy Oki, Founder & Director
Origami Whales Project

Lauren E. Campbell, Conservation Manager
Pacific Whale Foundation

Jeff Pantukhoff, President & Founder
The Whaleman Foundation

Sue Rocca, Biologist
Whale and Dolphin Conservation Society

Elizabeth Hogan, Campaign Manager for Oceans & Wildlife
World Society for the Protection of Animals USA

ITP Goldstein <itp.goldstein@noaa.gov>

STOP KILLING MARINE ANIMALS!!

Tatiana Giraldo <tagiraldo@gmail.com> Sun, Oct 14, 2012 at 7:00 PM
To: ITP.Goldstein@noaa.gov

This is horrible you must stop this!

--

Tatiana Giraldo

Energy Design Builders Inc.
License # 936588
347 Vetter Lane
Arroyo Grande, CA. 93420

Phone : (805) 473-0831
Fax : (805) 473-0831

Email : thayes.edbinc@earthlink.net

To Steve Edmondson
fax 707/578-3435
ph 575-6052

FAX TRANSMITTAL FORM

To: NOAA
Name: Habitat Protection
CC:
Phone:
Fax:

From: Terry Hayes
Date Sent: 9.18.12
Number of Pages: 2

Message:

Good Day,

Our local utility P.G.&E. is seeking permits to allow destructive sonic seismic mapping along the central California coast. These procedures would be deadly to marine wildlife, with little benefit. These measures could decimate our local fisheries and the entire marine ecosystem. I urge you to deny permits for this action, thus protecting our coastal environment.

Thank you,

Terry Hayes

TERRY HAYES

347 Vetter Lane
Arroyo Grande, CA.
Phone (805) 801-3925
Fax (805) 4730831
thayes.edoinc@earthlink.net

September 18, 2012

NOAA Fisheries
Office of Habitat Protection

Dear Sir,

I am contacting you in regard to the proposed seismic testing on our local coast by P.G.& E. for the continued operation of Diablo Canyon nuclear power plant. We locals are adamantly opposed to this action, as it will have no positive effect for the projected 64 million dollars it is supposed to cost. It will not prevent or diminish the catastrophic damage which could be the result of a seismic event. Nor would it minimize the danger posed by the poisonous waste being generated at that plant each and every day. It would have no positive effect on the cost we taxpayers will be charged for the storage and protection of all that hazardous waste from terrorists. In fact these costs will escalate enormously as we continue to produce more and more extremely deadly waste day after day. These costs will be the responsibility of us taxpayers, not the utility. The utility will walk away counting their money as we clean up their mess. At best, this mapping may show details of seismic faults under and around the nuclear plant which are already known to exist. This information may likely be manipulated to appear of less concern, so as to downplay the negative impact. Thus allowing P.G. & E. to push thru re-licensing of the nuclear power plant for another 40 years. This would be the pay off for jeopardizing the health of the marine life along our coastline. The negative effects to our local tourism, fishing and related businesses in our area should be enough to prevent this ill conceived plan. The possibility of such catastrophic death and destruction to our coastal wildlife is quite literally unconscionable. It is your charge to protect our coastal treasures, not permit them to be destroyed. I thought the coast and marine life were protected against destructive actions. The wildlife in our oceans belong to us all, not the few with money and power. The potential of such death and destruction is unacceptable. The discussion, as someone else so eloquently put it, should be how best to decommission, dismantle and dispose of Diablo Canyon nuclear power plant and its associated waste. Instead of pouring more money into this costly and dangerous form of power generation, more funding should be directed to emerging clean energy technologies. Please do not allow this proposed destruction to devastate our coastline. I'm sure your family will thank you for stopping this travesty, I know mine will.

Thank you

Terry Hayes

ITP Goldstein <itp.goldstein@noaa.gov>

PG&E mammal displacement

Tom DS <salmonfolk@gmail.com> Tue, Oct 16, 2012 at 11:42 AM
To: ITP.Goldstein@noaa.gov
Cc: Greg.Haas@mail.house.gov

Goodmorning;
I fish Drift Gillnets for swordfish off Morro Bay during the High Energy Seismic Survey [HESS]..
We are concerned about the displacement of mammals from inshore to our offshore fishing grounds.
We use accoustic pingers to create a wall of sound to warn mammals of the location of our fishing gear.
We feel if this permit for PG&E's High Energy Seismic Survey is granted it will cause a financial hardship on our fleet.
1) The sound waves from the survey will overwhelm our accoustic devices
2) There is strong evidence that many mammals will be impaired by the 260 decibel blasts occuring every 15 seconds.
3) The survey will cause mammals to change feeding and migratory patterns.
4) The first attachment shows the volume and travel distances of the 260 decibel blasts, as shown a much larger area of the ocean
environment will have impacts then the FEIR or the EA indicates.
5) The second attachment has been copied from NMFS letters with regard to this project.
We have made several attempts to bring our concerns to PG&E's John Shoals (Public Relations in charge of impact mitigation) for consideration
and he has denied that we may have adverse impacts to our fishery. We have supplied documentation to support our concerns.
The fishermen I represent respectfully request denying the Take Permit until a complete understanding of the displacement of the marine mammals
is addressed. It is our position that we will not be able fish during this survey.

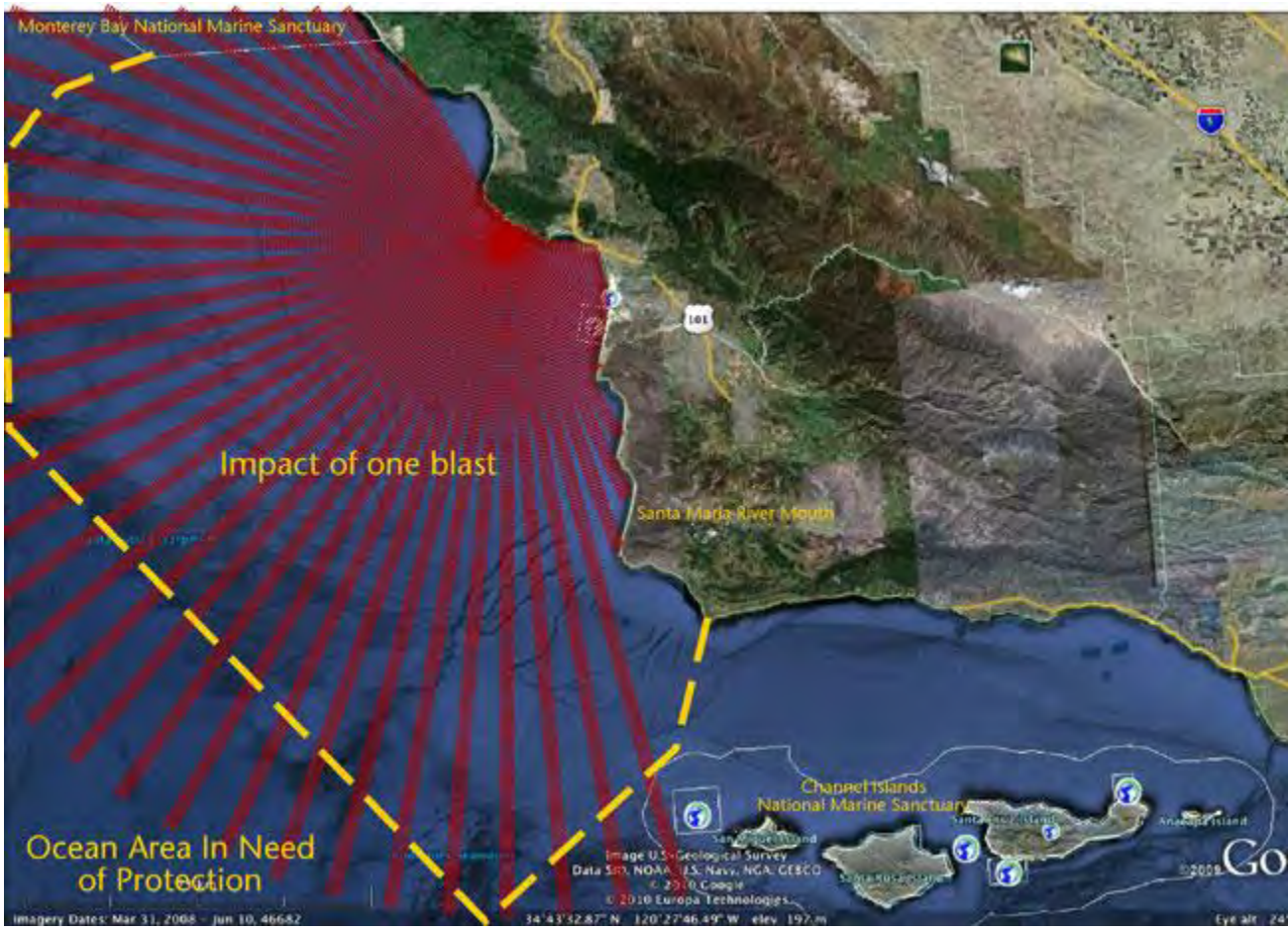
Thank you for your consideration
Tom Roff
Director of the Federation of Independant Seafood Harvestors

2 attachments

Extrapolating from map 1 is an approximation .doc
151K

Displacement of mammals to DGN.doc
444K

Extrapolating from map 1 is an approximation of the impacts of levels one and two around the testing areas as well as and more importantly, 1) the beach and recreational areas that one would assume have to be closed —— no mention of this in the DEIR; 2) illustrates the complete devastation to the kelp bed habitats from Pismo Beach north to above Cambria within the Monterey National Marine Sanctuary.



Shock Waves of One Blast

I couldn't find any reference to the following in your analysis;

> ***Pacific Highly Migratory Species FMP*:** Commercial and recreational albacore fishing, and commercial swordfish and thresher shark drift gillnet fishing (DGN) may be impacted by the proposed project. The proposed action would occur during the height of the DGN fishery and, while not fishing in the proposed action area, could be restricted if transit is restricted.

> NMFS is concerned about the proposed "Significant and Unavoidable" impacts to marine mammals: as outlined in the DEIR, that this project "would result in injury or mortality to marine mammals due to noise during seismic survey acquisition." One issue of particular concern to NMFS is the potential for the proposed activity to result in an inadvertent increase in interactions between marine mammals and the DGN fishery. In order to avoid the area of activity, marine mammals may move farther offshore, displaced by the acoustic disturbance and into the area where drift gillnets are routinely placed, leading to higher risks of interactions. Although these nets are required to have pingers and other measures to reduce the risk of entanglements with marine mammals, such measures were designed for use under normal circumstances and not for animals that may experience disturbance and/or trauma.

These statements are copied from NMFS letters to Ca. State Lands Commission.
While reading the Federal Register notice it seems the concerns vanished.

RECEIVED 10-15-12 PRI

October 10, 2012
Arroyo Grande, Ca. 93420

Dear Sir;

I am writing to ask N.M.F.S. to deny P. G. & E. permission for any more seismic blasting off of the California coast. I am a life-long commercial fisherman, trawling the coast from Pigeon Point to the Channel islands since 1943. All of my fishing carerr I have been involved in promoting good stewardship and a sustainable fishery. In the late 1940's we testified before Ca, Fish and Game Dept. and was successful in getting trawl net mesh size increased to allow escapement of the small fish. Later we managed to get the trawl fishery moved out to 3 miles instead of a hard to enforce fathom curve. In the early and mid 1960's many of us fishermen, and a few Hollywood notables protested the building of a nuclear power plant near an earthquake fault. It was a mistake then and now. In the early 1990's I served two terms on the Groundfish Advisory Panel for the P.F.M.C. and two terms on the National Marine Sanctuary Council Advisory Board, and ten years on the Calif. Seafood Council as a trawl representive. I care about the future of our fisheries. California has implemted marine preserves. no-take, no fishing zones, and the P.F.M.C. has a rock cod conserveation zone from 60 to 150 fathom. Fish in these areas, especially juveniles and larvae are being impacted by seismic blasting. I strongly urge you to deny any further damage to our envirionment. I am 90 years old, still fishing, and working that others may have the same opportunity. We are grateful for any help the N.M.F.S. can give.

Sincerely yours, and "His"

Travis O. Evans
Ph. 805-489-6221 270 Larchmont, Arroyo Grande, 93420

ITP Goldstein <itp.goldstein@noaa.gov>

OPPOSED to PGE Seismic Testing

LEONARD J BERRY <lbval@sbcglobal.net> Fri, Oct 12, 2012 at 3:30 PM
To: ITP.Goldstein@noaa.gov

I am writing to implore National Marine Fisheries Service to deny the permit for PGE to do seismic testing off of our coast. This testing will not ensure our health and safety. We already know that Diablo Canyon Nuclear Plant is too close to several faults to be "safe". Fish and Game Commissioner Richard Rogers has stated that this testing would "cleanse the Point Buchon Marine of all living marine organisms." At best, it is known that there will be harmful effects to marine mammals; PGE lists them in their "take". This cannot be "mitigated". As the agency entrusted with the protection of marine life, please stop this deplorable plan before even 1 marine mammal and other marine life is harmed.

Thank You,

Valarie Bennett

ITP Goldstein <itp.goldstein@noaa.gov>

NO seismic imaging for Diablo

Wesley Schweikhard <wschweik@gmail.com> Sat, Sep 29, 2012 at 3:16 AM
To: ITP.Goldstein@noaa.gov

Hello,

Please DO NOT ALLOW the PG&E seismic imaging project to go forward. Our local fishing and tourism economies will be devastated and our local wildlife will be obliterated (whales, dolphins, otters in the thousands, and entire stocks of fish). Please DO NOT ALLOW the project to go forward. What new knowledge can be gained regarding the KNOWN faults that will contribute to our safety? NONE. The timing and severity of an earthquake or potential tsunami will not be discovered by these tests. Any gained knowledge will be extremely marginal. And what is the cost? THE ECOSYSTEMS AND WILDLIFE OF OUR COAST (in which there are 3 hard fought marine protected areas), and OUR ECONOMY. Do not destroy the central coast of California. These tests will do just that. PLease bring PG&E to a halt. Please work for a better future. These test are only chasing bad money and bad knowledge, and do little to help us all move forward.

Thank you.

Sincerely,
Wesley Schweikhard
3199 Ocean Blvd.
Cayucos CA 93430

ITP Goldstein <itp.goldstein@noaa.gov>

Fwd: Please stip this testing.. We have read all there is on this test.. It does not help us learn any more then we already know..

Howard Goldstein <howard.goldstein@noaa.gov> Tue, Oct 16, 2012 at 9:06 AM
To: ITP Goldstein <itp.goldstein@noaa.gov>

---------- Forwarded message ----------
From: **Wilhelmina Rodenhuis** <blondehare@charter.net>
Date: Tue, Oct 16, 2012 at 12:22 AM
Subject: Please stip this testing.. We have read all there is on this test.. It does not help us learn any more then we already know..
To: Howard.Goldstein@noaa.gov
Cc: joseph.sebrosky@nrc.gov

Dear Mr. Goldstein,

Because the staging parts of this project having been allowed to go ahead without the peoples input or a complete regulatory process, the baselines are shifted, and no study results will be trustworthy or accurate.Also, the whales are endangered already, and don't need to be harassed or worse. And because PG&E has stated they will make no plant upgrades regardless of the seismic results, seismic testing does nothing to improve our safety. Finally, this area being the core home of the species, Harbor Porpoises and Otters could be rendered completely extinct if this unnecessary seismic testing is allowed to go forward.

Signed,
Wilhelmina Rodenhuis

Faith makes all things possible, but no one said it would always be easy.

--
Howard Goldstein
Fisheries Biologist
NOAA Fisheries
Office of Protected Resources
Permits and Conservation Division
1315 East West Highway, Rm 3539
Silver Spring, MD 20910

U.S. Department of Commerce
Office: 301-427-8417
Fax: 301-713-0376
Howard.Goldstein@noaa.gov
Web: http://www.nmfs.noaa.gov/pr/permits/incidental.htm#iha

www.nmfs.noaa.gov

NOAA FISHERIES

ITP Goldstein <itp.goldstein@noaa.gov>

No!

xariz77@gmail.com <xariz77@gmail.com> Sun, Oct 14, 2012 at 10:32 PM
Reply-To: xariz77@gmail.com
To: ITP.Goldstein@noaa.gov

No need for more dolphin killings! Plese stop
Sent from my BlackBerry® smartphone, powered by CREDO Mobile.